POWER PLANT ENGINEERING

Established Over 33 Years

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Monkey Business

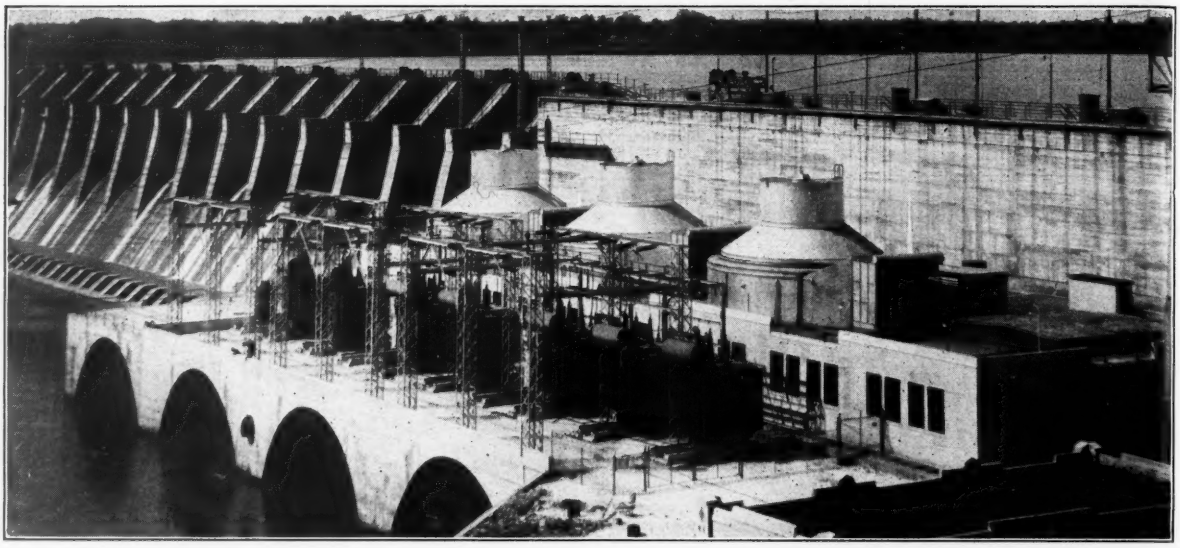
SUCH AN EXPRESSION, which our good friend Noah Webster labels U. S. slang, admittedly should have no place in the pages of the leading power plant journal. Monkeys, however, have had such a prominent place in the development and controversies of mankind through the ages that we thought one fall from grace in the course of 33 yr. service to the power plant field would be permissible if for no other reason than to serve as the exception that proves the rule.

The world and particularly the engineering profession are much indebted to those curious individuals who, trying to look behind the veil and learn the mysteries of nature, incurred the contempt and sometimes enmity of the populace which believed in leaving well enough alone and trusting to Divine Providence.

Monkey business in those days was not a paying proposition to the individual although the world today is reaping the benefits of developments which can directly be traced back years and sometimes centuries.

Today monkey business is highly organized and graced by the more dignified title of research. No problem is too difficult and no avenue of possible improved efficiency too obscure to be attempted. Many times present knowledge makes easy the solution of problems which baffled the investigator of years ago when research was monkey business.

Such a condition prevails in the field of submerged combustion. For almost a century, men have been trying to eliminate certain inherent boiler and furnace losses by burning the fuel in direct contact with water. The history, limitations and practical applications of such burners are covered briefly on page 944.



Norwood 62,000-Kw. Hydroelectric Development

OUTDOOR CRANE AND LOW SUPERSTRUCTURE ARE FEATURES OF NEW PLANT OF CAROLINA POWER AND LIGHT CO. ON PEE DEE RIVER

INSTALLATION of hydroelectric stations with low superstructure and served by an outdoor gantry crane is not a new idea, yet there have been few installations of this type incorporating such large generating units or such interesting details as that of the Norwood Hydroelectric Development of the Carolina Power & Light Co. at Mt. Gilead, N. C. This plant, completed in 1928, has a capacity of 77,500 kv-a. or 62,000 kw. in three units, making power at 13,200 v., which is stepped up to 110,000 v. and transmitted to a substation that in turn feeds it into the transmission lines and interconnected systems of the district.

Norwood plant is on the Pee Dee River in North Carolina just below the junction of the Yadkin and Uharrie Rivers, which come together at the head of the storage pond. The dam at Norwood backs the water up to the tail-water of the Falls plant of the Tallassee Power Co. about 18 mi. upstream and provides a storage reservoir of about 6000 acres in extent.

CRANE IS INSTALLED OUTDOORS

By installing an outdoor gantry crane for handling the generating machinery, the height of the superstructure is reduced to that necessary to house only the operating equipment. Ample protection from the weather as well as adequate accessibility for repair is provided in this case by sheet steel housings over the generators.

As shown in the photographs and in Fig. 3, the installation consists of the three generating units (space being left for a fourth future unit, an earth dike, a concrete gravity dam with a spillway section 730 ft. long equipped with Tainter gates, a switchyard on the hill overlooking the station and an attractive village for the operators, north of the switchyard.

Water wheels are I. P. Morris Francis type units. Two of these, units Nos. 1 and 3, are of 31,100-hp. capacity, designed to operate at 70 ft. head, 90 r.p.m. Unit No. 2 is of 25,600-hp. capacity, designed to operate at 70 ft. head, 75 r.p.m. The smaller capacity wheel, which has a lower specific speed than the others, is used for more efficient load regulation.

DETAILS OF GENERATOR MOUNTING

These wheels are set as shown in Fig. 1, discharging into Moody spreading draft tubes. They drive three umbrella-type Allis-Chalmers generators, Nos. 1 and 3 rated at 22,000 kw., 27,500 kv-a., 13,200 v., 3 phase, 60 cycle, and No. 2 rated at 18,000 kw., 22,500 kv-a., 13,200 v., 3 phase, 60 cycle.

Steel housings, fabricated by Connery & Co., Inc., protect these generators from the weather and at the same time furnish a jacket through which air is drawn for ventilating the generator windings. Fans on the generator rotor draw the air in at one side of the casing, through an extension of the casing shown in Fig. 2-F. In this extension is mounted an air washer, designed and built by the Carrier Air Conditioning Co., that washes the air by passing it through sprays from spray nozzles. The air then passes around the jacket space in the casing, entering the generator near the bottom of the casing through openings in the base ring, as shown by the arrows in Fig. 1. It then passes up through the generator winding and out through the top of the casing.

A damper at the neck of this opening can be moved up and down, to control flow of air, by a motor-driven hoist actuated by push-button from the control room. This damper also serves as a baffle to deflect rain, while the generator itself is covered with a roof of sheet metal to shed rain at the sides. Each air washer is supplied with water by a Buffalo single-stage pump driven by a 25-hp. G. E. motor.

Bearings and Lubrication

The Kingsbury thrust bearing is just under the top arms of the generator rotor and is supported on a bearing spider which rests on the concrete supporting barrel. The generator guide bearing is contained in the bearing spider just below the thrust bearing. The lower guide bearing is just above the water wheel. These bearings are all of the babbited, oil-lubricated type; electric alarms and oil gages and sight flow indicators are provided on a panel to indicate condition of lubricating oil at all times.

With the 150-t. Morgan crane, Figs. 1 and 2B, the generator rotors and water wheels can be lifted out of their settings for repairs or maintenance work and conveyed to the east end of the plant, where a machine shop, Fig. 2C, is installed. A complete rotor can be removed and another installed in 10 hr. The crane runs with one leg on the top of the dam as shown, and can pick up 250 t. on the center line of the units if there is no impact. On the dam end of the crane, a 75-t. hoist is mounted for handling the headgates. As the Norwood plant is many miles from a city, these complete facilities for maintenance work are of vital importance.

Governors, pumps, buses and other auxiliaries, as well as the control room and machine shop, are on the level formed by the top of the penstock and water wheel foundations, as shown. These auxiliaries and the general operating conditions will be discussed after considering the dam and water control equipment. The method of operating the plant will be better understood after its equipment is described.

Dam and Headworks

Water is led to the wheels through the concrete dam, Fig. 1, by 23-ft. steel penstocks, each of which can be closed by a 24 by 26-ft. Stoney roller intake gate actuated by a motor-driven screw hoist of 175 t. capacity. Ahead of the gates, which are of structural steel weighted with concrete, are the screens, 3 bays per unit and 6 sections per bay, cleaned by a Newport News traveling trash rake that moves along a track at the top of the dam. This track also provides passage for a 20-t. locomotive crane for miscellaneous work or for handling logs or large debris that the rake cannot handle. Dirt picked up by the rake is dumped into the sluice trench just under it in the top of the dam and is floated over to the west end, where a 10 by 14-ft. trash gate, opening downward, is provided between the dam and the spillway sections. Head gates, racks and rake were supplied by Newport News Shipbuilding & Dry Dock Co. The intake gate hoist was furnished by Coffin Valve Co.

An inspection tunnel runs through the dam and spillway, Fig. 1, in which is a compressed air line with branches leading to the under side of the head gates and trash racks, so that debris that gets stuck there can be dislodged. Each penstock has a 24-in. drain controlled by a Kennedy 24-in. gate valve, which unwaters the pen-

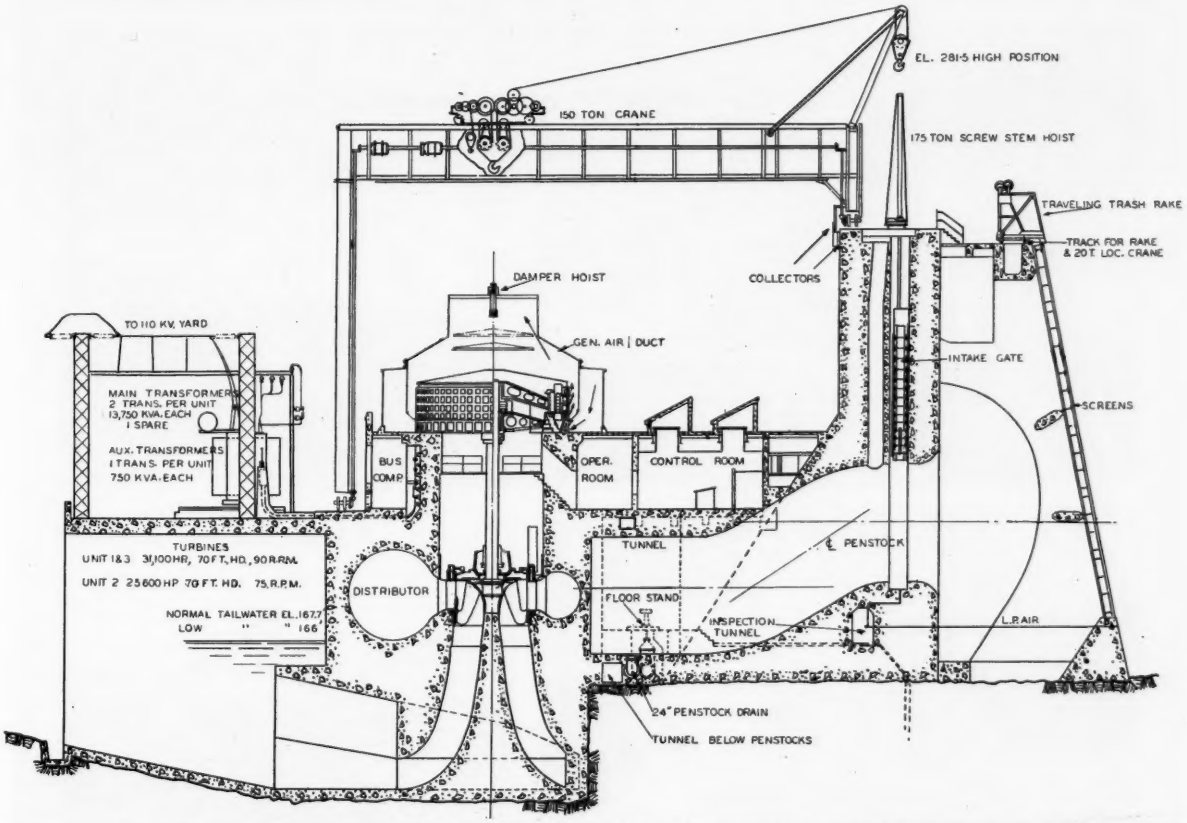
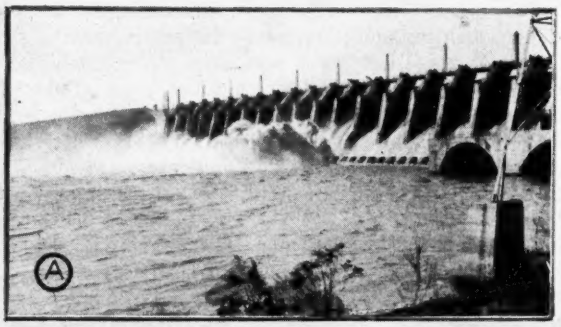
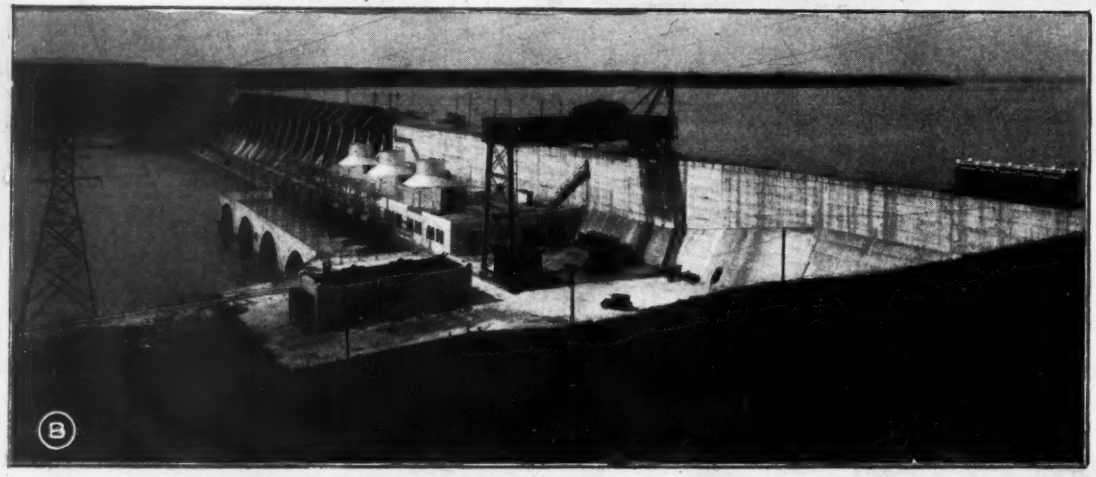


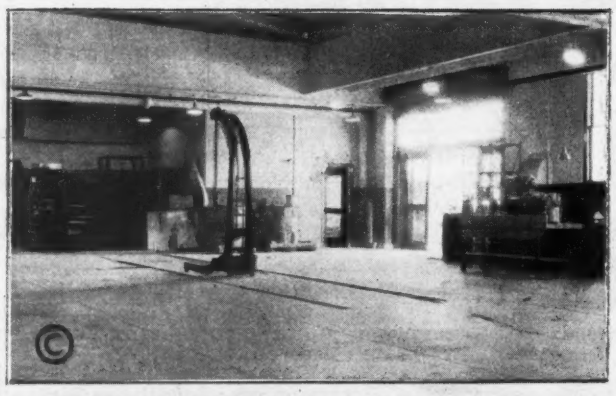
FIG. 1. CROSS-SECTION THROUGH GENERATING UNITS AND DAM AT NORWOOD, SHOWING METHOD OF VENTILATING GENERATOR, LOCATION OF CRANE AND DETAILS OF HEADWORKS

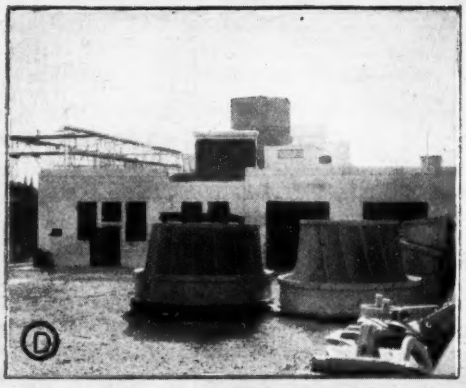
Fig. 2 Interesting Details at Norwood

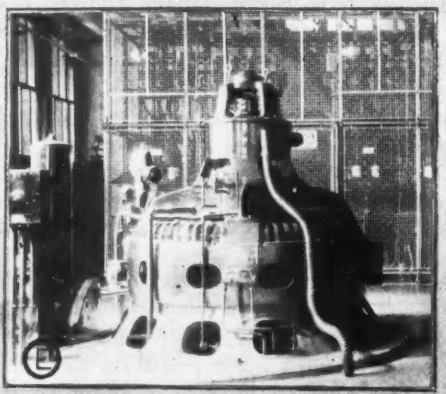
A—Spillway discharge through one gate, showing action of apron and baffles. B—Panorama of Norwood. C—Machine shop contains complete equipment for maintenance work. D—Two spare water wheel runners outside machine shop. E—House generator, with general auxiliary bus in background. F—Generator air intake contains air washer.

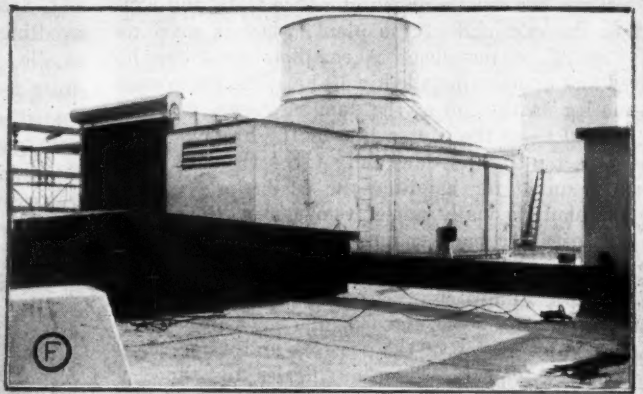












stock to a sump, from which the water is pumped by sump pumps.

Details of Spillway and Dam

Spillway section of concrete, with a cross-section as shown in Fig. 3, is 730 ft. long, with a 175-ft. abutment and a 1200-t. earth dike on the end opposite the power house. The spillway is of gravity section, with an apron and toothed baffles. It is controlled by 18 Tainter gates, each 34 ft. long and 24 ft. high. These are raised or lowered by Maine Electric Co. 6-hp. motor-driven, sprocket chain hoists on the top of the dam; each motor drive is switched on at the control room but is operated by a push-button control at the motor.

For fire protection and general station service, water is taken from the pond above the dam. For fire protection, two centrifugal pumps are provided, under automatic control, so that a small Aurora Pump Co. motor-driven centrifugal unit is thrown into service first, and if this is not sufficient a larger Worthington centrifugal Underwriter's fire pump is automatically cut in. A pressure tank provides an air cushion to keep constant pressure on the fire lines, and, as soon as the head given by this tank goes below a certain point, the fire pumps go into service automatically.

A feature of this station is the use of the triangular-shaped space between the control room and the dam for both a conduit run and a ventilating duct. The various

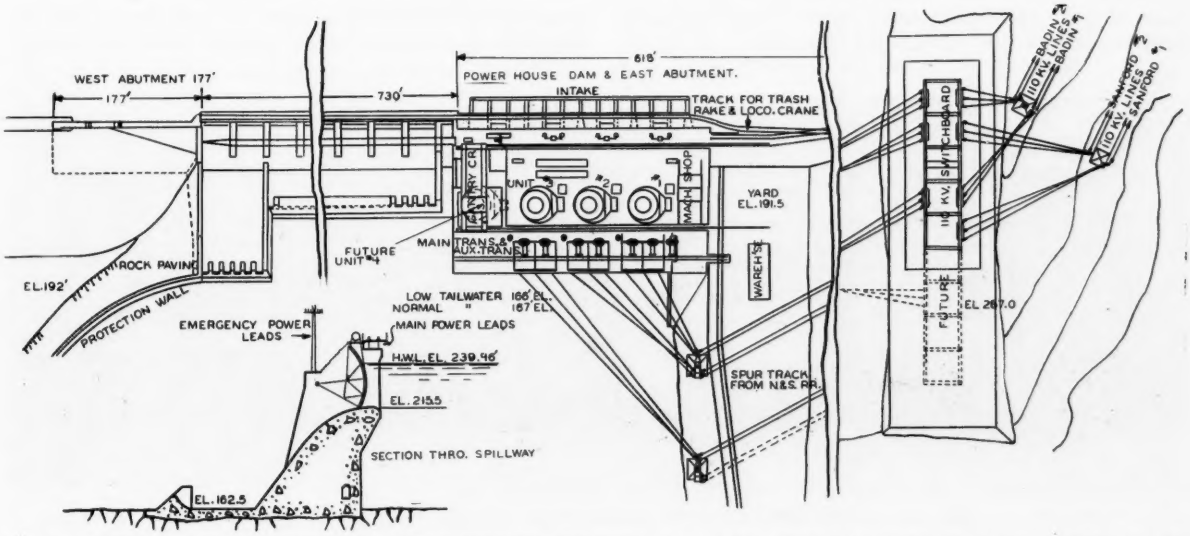


FIG. 3. GENERAL PLAN OF NORWOOD DEVELOPMENT SHOWING DAM AND SPILLWAY, TRASH GATE, GENERATORS AND ELECTRICAL LAYOUT

Figure 2A shows the spillway section with water spilling through one open gate.

Governors and Exciters

In the operating room below the generators are the various auxiliaries. Controlling the turbine gate mechanism is a motor-driven I. P. Morris Pelton type governor, with its motor-driven oil pump and accumulator tank, all located near the generator supporting barrel.

Each generator has its own G. E. exciter set in the form of a 200-kw., 275-v. d.c. generator driven at 1200 r.p.m. by a 300-hp., 550-v. induction motor, a similar spare unit being provided. At the west end of the room is the house generator unit, consisting of a 650-hp. Leffel water wheel, controlled by a Woodward governor and driving a 450-kw., 550-v., 600-r.p.m. Westinghouse generator supplying power to the auxiliary bus as will be explained later.

Compressed air for general station service and for blowing under the gates is supplied by an 8 by 8-in., 100-lb., Ingersoll-Rand air compressor, belt driven by a G. E. induction motor. Air at 250 lb. pressure for the governor system is supplied by a smaller direct-driven compressor. Three American Well Works vertical sump pumps, driven by G. E. motors, discharge the water from the sumps to the tailrace when the penstocks are being unwatered.

leads from the auxiliaries and switchyard run to the control board through this space, as shown in Fig. 1. Since it is open at one end, air is drawn through it by Ilg Electric Ventilating Co. fans, which discharge into the control room and operating room.

The machine shop at the east end of the station contains power hack saw, pipe cutting and threading machines, grinder, shaper, lathe, drill presses and blacksmith's equipment. A large hatchway in the roof permits the crane to lower generator or water wheel parts into the shop. At the opposite end of the building is the superintendent's office.

Main Switching Is Done on High-Tension Side

Let us turn now to the electrical equipment and methods of operating the plant. Generation is at 13,200 v.; the generator leads go directly to the transformers on the deck outside the operating room, over the tailrace. There are no switches here, except disconnecting switches, as all switching is done on the high-tension side. Each unit is served by two 13,750-kv-a., 3-phase, G. E. transformers in parallel, which step up the voltage to 110,000. A spare transformer is provided. From these transformers, the leads go directly to the high-tension switching station on the hill above the plant, Figs. 3 and 4. Here the circuits are handled by 132,000-v., quick-acting Westinghouse circuit breakers,

remote controlled from the control panel. All synchronizing is done through high-tension networks.

Power Supply for Auxiliaries

Each generator has a unit bus system, the buses being installed in compartments in each water wheel enclosure, Fig. 1. This supplies all the auxiliaries for each machine. Power comes to the auxiliary bus, under normal conditions, from the main transformers through a 750-kv-a., 3-phase G. E. transformer that steps down from 13,200 to 550 v., the voltage at which all auxiliary motors operate. From the unit bus of each machine, its governor fly ball motor, governor oil pumps and air washer pumps take their power.

Remaining auxiliaries and station lighting and machine shop circuits take their power from a general auxiliary supply bus, which can be fed by any one of the unit buses or by the house generator. The exciters are also connected so that any generating unit can take excitation from the others or from the spare exciter unit. The house generator serves the further important purpose of supplying power to the spare exciter or auxiliaries when starting up one of the main units and, in case all main units are shut down, it supplies lighting and general station service.

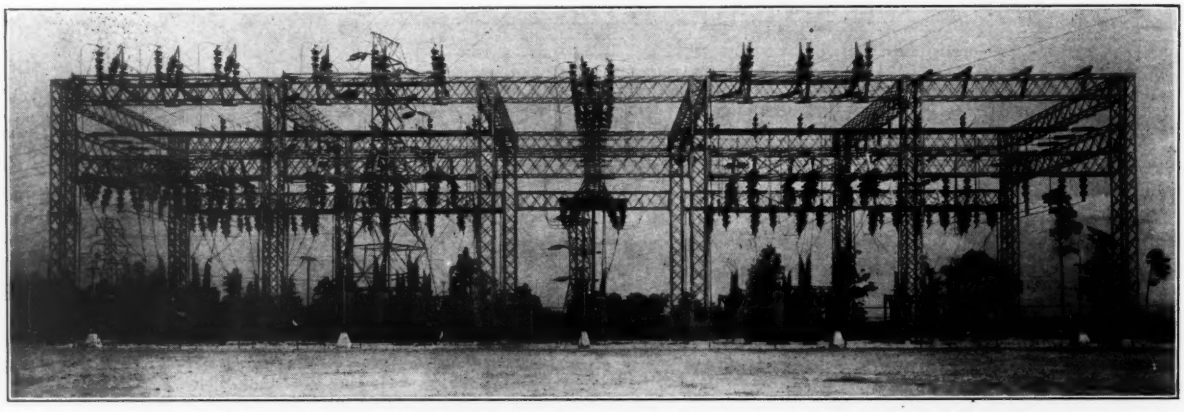


FIG. 4. ALL SWITCHING AND SYNCHRONIZING ARE DONE IN THIS 110,000-V. SWITCHYARD

Methods of Operation

Units No. 1 and 3 are normally operated at the gate opening that gives best efficiency, while No. 2, the smaller unit, operates over a long range of load, to take fluctuations in load. Ordinarily the plant is supplying base load to the system into which it is connected.

The plant is connected to the system by two double circuit 110,000-v. steel-tower lines, one running to the Cape Fear switching station located near Moncure, N. C., the other going to Badin, N. C. By these connections, the plant ties in with the systems of the Duke Power Co. and the Tallassee Power Co.

Control Room

In the control room is a bench board for control of main units and auxiliaries as well as of head gate and Tainter gate hoists. An instrument panel carries the meters and instruments, all meters and switches being of General Electric make. A G. E. totalizing and recording watt-hour meter is provided and the board also carries Leeds & Northrup temperature recorders for the generator armature windings and an Esterline-Angus ground detector. A storage battery, furnished by The Electric Storage Battery Co., supplies power for the control equipment.

To operate the station, 12 men are required. There are three shifts, requiring two operators per shift, the other two men being used for outside work. The operating force lives in an attractive village just north of the switchyard. The station itself is a model of good housekeeping and its appearance is enhanced by the landscaping and the generally pleasant character of the surrounding country. Frank M. Nash is superintendent.

The project was designed by the engineering department of the Electric Bond and Share Co. and constructed by the Phoenix Utility Co. and the Hardaway Contracting Co.; the latter company did the concrete and unwatering. We are indebted to all of the above companies for cordial coöperation in visiting the plant and in obtaining data.

According to a recent Department of Commerce report, a total of 940,806 net tons of raw fuel of all kinds was briquetted in 1928; 40 per cent of this amount was anthracite and semi-anthracite, 52 per cent semibituminous and bituminous coal (including small amounts of semicoke) and 8 per cent subbituminous coal and carbon residue from the manufacture of oil gas. As the weight of binders added was greater than the weight of the moisture expelled, there was a net gain of 6617 t. during the process of manufacture.

There were no radical changes in binders used by briquetting plants in 1928. Asphaltic pitch was employed as a binder, either alone or in combination, by 13 out of 21 active plants. Eight producers used it exclusively, two used asphaltic pitch and coal-tar pitch, one a mixture of asphaltic pitch and patent binder, one asphaltic pitch and molasses residue, one asphaltic pitch and starch, one coal-tar pitch, two sulphite liquor, one sulphite cellulose and two patent binders. Two plants briquetting carbon residue from oil gas required no binder.

Five of the producers using a binder, whose total output was 25,757 t., reported that they recarbonized the briquets coming from the presses to drive off smoke from the binder.

Meters Indicate Proper Combustion Control

Trend of Lines on the Steam Flow Chart Indicates How to Save Coal for Your Company and Work for Yourself. By Walter N. Polakov*

IT TAKES ABOUT 2 lb. of coal to generate one kilowatt-hour in present day power plants. Economy in coal is an important item in power cost reduction. Our principal efforts should be directed, therefore, to a more complete use of the heat units stored in coal.

Heat value of coal depends upon its composition. A bituminous coal may have the following composition: fixed carbon 64 per cent, volatile matter (gas) 27 per cent, ash 7 per cent and moisture 2 per cent. The coals younger in age of development, such as bituminous coal, contain the greatest amount of moisture and volatile matter; the older the coal, as anthracite coal, the lesser amount of moisture and volatile are present.

Smoke Formed by Distillation of Cooled Gases

In the process of burning, volatile matters are first distilled off from the heated coal. If the hot burning gases come in contact with cold surfaces such as boiler tubes, complete combustion will be prevented if the gases are sufficiently cooled. Smoke due to the distillation of hydro-carbons will be formed and this and the waste gases resulting will be lost. Therefore, for low set boilers, that coal is best which contains least amount of volatile matter.

Fixed carbon is the solid part of the coal that turns into coke after all gas is driven off. It burns more slowly than the gas but it always gives off the same amount of heat if burned completely, namely, 14,650 B.t.u. per lb.

Approximately one-fifth of the air is oxygen and combustion can take place only if oxygen is present; therefore, coal can burn only as fast as the oxygen from the air comes into contact with hot coal. If part of the carbon combines with only one part of oxygen forming CO, carbon monoxide, only 4430 B.t.u. are produced. But if one part of carbon combines with two parts of oxygen, forming CO_2, carbon dioxide, 14,460 B.t.u. are liberated.

Basis for CO_2 Determination

Determination of the amount of CO_2 produced is made by dissolving the gas in caustic soda in an Orsat analyzer. By washing the furnace gas in a solution of caustic soda, the volume of gas measured off will shrink in a definite proportion as the CO_2 is dissolved.

We must have sufficient draft to maintain rapid combustion. If only enough air is furnished to form CO instead of CO_2, the coal will burn but we will lose 10,000 heat units out of every 14,460 per lb. of carbon. Now, if we provide draft by letting hot burned products flow up the chimney, drawing fresh air in through the grates, a continuous supply of oxygen will be supplied. The more coal you wish to burn per square foot of grate, the more draft you will need.

If, however, you let in more air in the furnace than is needed to form the proper percentage of CO_2, then with each one-fifth of oxygen there will be about four-fifths of nitrogen and other gases drawn into the furnace.

Suppose, now that the outside air is 70 deg. F. and that the furnace is 2200 deg. It is easy to see that the fire and furnace will be cooled off and two things, both bad, will take place. First, your volatile gases will not burn completely, if at all, thus turning into smoke and wasting twice as much heat per pound as the volatile gases produced; second, the heat from the carbon of the coal will be used to warm up the excess air instead of heating the boiler water and making steam.

Waste Results from Improper Air Supply

Either too much or too little draft, therefore, results in waste. It is bad enough to let the furnace door remain open too long but it is ten times worse to have the damper set incorrectly by a pressure gage and not know it because the coal on the grate and the layer of ash will fool you every time. The only way to know, accurately, what draft you need to supply in order to burn coal economically, is to measure, exactly, the air you need to get the most heat out of coal.

Steam is drawn from the boiler at widely varying rates. The pressure will go down or up if you fire uniformly but you avoid drop of pressure as well as blowing-off of safety valves by adjusting the damper according to the pressure as shown on the gage. But this adjustment is too late. The higher the pressure the more heat the boiler water contains so that when the pressure drops a little, the hidden or latent heat in the boiler water drives a little more steam out of the water without the aid of the fire in the furnace. Then, when the pressure is already too low for operation, there is no reserve and because the fireman is not warned that the steam was coming out of the boiler faster than it is made, he has to fire faster and open the damper wider but in his hurry he loses the cream of the coal in smoke.

Steam-Flow Meter Is Good Operation Barometer

Therefore, the first thing for the fireman to watch is how fast steam flows out of his boiler and this is indicated by the steam-flow meter which has one pen filled with red ink to indicate the change in steam consumption and another pen filled with blue ink to indicate the change of rate of air supply to the furnace. The instrument is so adjusted that when the red line, showing the steam flow and the blue line showing the air flow are running into each other, correct adjustment of draft is indicated, the draft being just right to maintain complete combustion of one pound of coal for every 10 lb. of steam generated.

Reduced Draft by Clinker Formation Indicated

When you have bad clinkers or coal piled thicker on the grates than necessary, the proper draft will not pull through enough air and your blue line will start to go down. This serves as a warning that you should pull out the clinkers or shake down the grates to let enough

*Consulting Engineer, New York City.

air go through them. Again, if your fires burn low or develop a bare spot on the grate, the draft will pull too much air through the fire bed and cool off the boiler. In this case, the blue line will run above the red line and that will serve as a warning that you should cover the grates a little more until the red and blue lines are together again.

It may be that the red line will begin to go up because more steam is used in the plant. In this case, you will need to produce more heat at once in order to avoid a pressure drop. To do this, you will have to open a damper slightly and throw in a few shovelfuls of coal in order not to be caught unawares. At another time, the red line may be going down because less steam is being used. In this case, you can save coal by choking the damper at once without waiting for the steam pressure to rise too high and the safety valves to rattle. By the aid of the steam-flow meter, you are enabled to know at once what to do before the steam pressure goes down or the safety valve blows and by doing it you save coal. The instrument would indicate whether or not you were firing correctly but that does not mean, necessarily, that your boiler was absorbing all of the heat it should.

Heat Transmission Loss Indicated

There may be conditions, such as where too much soot covers your boiler tubes, where it takes more coal to make steam than it should because only part of the heat will get through the tubes, the other part being discharged from the chimney. Whether this is so or not will be indicated by your flue gas thermometer which records this temperature in a green line on the chart. When this green line rises, one of two things is indicated. Either your boiler is dirty or your baffles are not tight. This indication enables you to attend to repair or cleaning before you burn a pile of coal to heat the clouds. Of course the temperature of the flue gases will go up also when you are forcing your boiler but in this case your red steam line will go up also. After blowing the soot off your tubes, you may see how the green line will go down and that will give you the idea where it should be for any load and when it is time to blow off the soot.

Gas Composition Checks Instrument Accuracy

To check the instrument to see whether it is set correctly, so far as the red and blue lines are concerned, it is well to test, from time to time, the composition of your flue gas. The flue gas should contain 12 per cent or more of CO_2, about 7 per cent of free oxygen and no CO at all. If you have more than 7 per cent of oxygen, your draft is too strong for the load and the blue pencil will have to be adjusted. If your CO_2 is more than 14 per cent and there is also some CO shown by analysis, it proves that you have not enough draft for your load. In both cases, coal is being wasted and you are making your own work harder at a loss to your company.

You will soon find out that the easiest way to spare elbow grease and save coal for your company is to maintain a proper setting of the damper, always keeping the red and blue lines on your chart together. You will also learn that firing heavy means wearing yourself out, producing more clinkers than necessary and firing considerable coal that does not make steam.

You will see also that when the red line, showing steam flow, is going down, it is wise to speed up the feed pump a little to take advantage of the coal on the grates and heat up reserve water; while again, when the steam flow goes down, it is wise to slow down the feed a little to check the dropping steam pressure by using up the reserve water.

It has been said that the laziest man in town is the best fireman. This is because he usually uses his brain instead of his back. A woodpecker uses the outside of his head; a good fireman uses the inside of his. Instruments in your plant, such as indicated, give you something to think about and help you to do your job better but they will not think for you. They are not automatic regulators.

Rehabilitation of Steam Power Plants

Consideration of Elements Governing Rehabilitation; Methods Used to Improve Efficiency and Enlarge Capacity. By C. F. Hirshfeld*

IN A GENERAL way, the exceedingly rapid evolution of the art of generating electric power is known to all who have more than a casual contact with it. Even those whose daily business consists of power generation, however, frequently fail to appreciate the speed with which we have advanced or the significance thereof. The graphs shown in Figs. 1, 2, 3, 4, 5 and 6 may serve to visualize the rate of progress. The significance of the development, however, cannot be shown by such curves.

In the first five of these figures, the areas within which representative station practice has fallen are indicated by cross hatching and an attempt has been made to indicate what might be called conservative practice or majority opinion by means of a curve drawn through each area.

The curve given in Fig. 6 is similar to one that has appeared in print several times within the past few years. It represents a remarkable procession in the direction of lower thermal costs. The decreased thermal consumption is, of course, not self-justifying because it may have been obtained with more than a compensating increase of fixed charges.

Figure 7 shows values to which little attention has been given in the literature of this subject. The increasing output per man-hour is in line with the general movement throughout the industrial world. In this case, it is brought about largely through improved load factor combined with the use of boilers and turbines of ever increasing capacity per unit.

From the executive's point of view, the rapid advance indicated in these figures has had two opposing results. On the one hand, the total cost of producing power has been decreased. On the other hand, the rate

*Chief of Research Dept., Detroit Edison Co. Abstract of paper presented at A. I. E. E. Summer Convention, June, 1929.

of obsolescence has been high, therefore invested capital has been impaired. The net result of all the forces concerned has been a gradual but consistent lowering of the selling price of power. But the decrease in this price has naturally not been as great as it would have been had it been possible in some magic way to wipe out of existence the older and less efficient plants as more modern ones became available.

The situation from one point of view is shown in

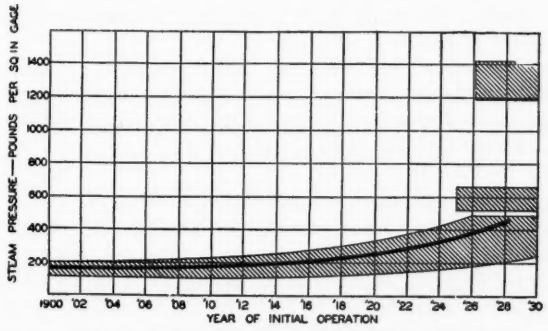


FIG. 1. INCREASE IN STEAM PRESSURES

Fig. 8. The solid line represents the thermal performance for a typical metropolitan system in which the rate of growth has been rapid. The dotted line shows what the values would have been if at the time of each improvement all earlier equipment could have been junked and the required capacity obtained with equipment similar to that just installed. One of the problems of the executive of light and power companies is to deter-

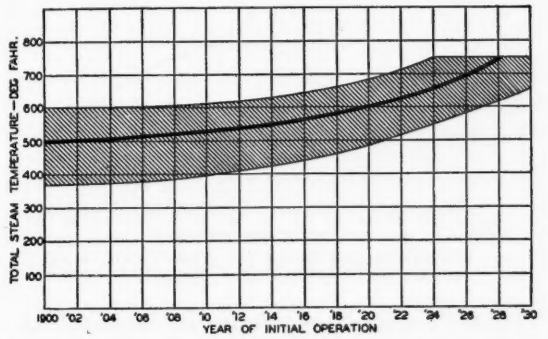


FIG. 2. INCREASE IN TOTAL STEAM TEMPERATURE

mine from time to time just how far he is justified in moving values such as those shown by the solid lines nearer to those shown by the dotted ones. Putting it in another way, the problem is to determine from time to time that balance between production and capital charges which will represent the best compromise for all concerned. It is out of this problem that we get rehabilitation and reconstruction of power plants.

Conditions Which Make Rehabilitation Profitable

Consideration may be given to some of the things which cause rehabilitation or even complete replacement of power plants. The more important of these are listed below with certain remarks which indicate the conditions under which they may or may not be significant.

1. The plant may be thermally inefficient in comparison with current standards of performance. This consideration is generally significant when the plant in question represents a large part of the total generating capacity and therefore a large part of the investment; when it occupies a strategic position in the system with respect to receipt of fuel or distribution of load so that its extensive use is required; when it occupies land which has appreciated greatly in value so that the maximum of return must be obtained from it, if it is to be retained; and, in general terms, under any other conditions which make the cost of fuel at this plant a very significant part of the company's annual expenditures.

2. The plant may be inefficient in the use of man power. This consideration is generally not of itself

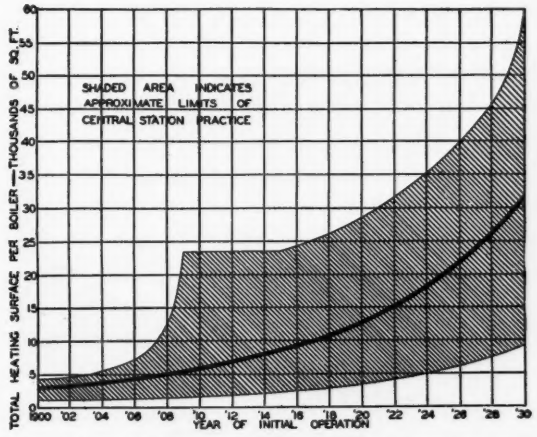


FIG. 3. INCREASE IN PHYSICAL SIZE OF BOILER UNITS

a decisive one but is one that is taken into account in combination with others. It is serious in cases where labor trouble is to be expected and it may be serious when the plant in question represents a very large part of the total plant capacity.

3. The plant may be inefficient in its use of ground area. This becomes important in the case of land which

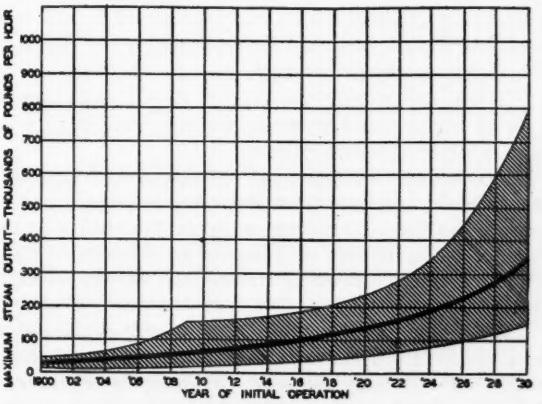


FIG. 4. INCREASE IN STEAMING CAPACITIES OF BOILER UNITS

has appreciated greatly in value, when the plant is particularly favorably located with respect to water or fuel supply and when the load conditions in adjacent territory make greater generating capacity on the site imperative.

4. The plant may be inefficient in its use of invested capital, as by occupying a larger building than necessary, operating boilers at low steaming rates, etc. This

consideration is of importance only when the plant represents a moderately large part of the total plant investment or when the location becomes of particular importance for reasons such as those given in preceding paragraphs.

FACTORS ENTERING THE PROBLEMS OF REHABILITATION

It is practically impossible to set down definite rules or even guides regarding the rehabilitation of steam power plants. A few outstanding facts may, however, be indicated.

In most cases, both improvement of thermal efficiency and increased capacity will be possible, and it

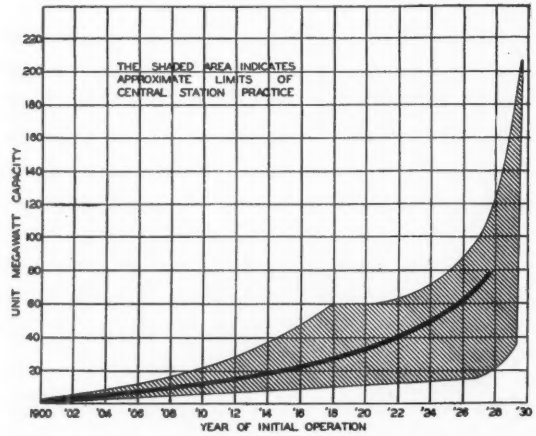

THE SHADED AREA INDICATES APPROXIMATE LIMITS OF CENTRAL STATION PRACTICE
UNIT MEGAWATT CAPACITY
YEAR OF INITIAL OPERATION

FIG. 5. INCREASE IN MAIN UNIT TURBINE SIZES

is necessary at the start of the problem to consider which of these possibilities, if either, is to be favored. Usually the possibility of increased capacity should be given first consideration because certain limits to such increase are so easily discovered.

If the power could be got away if generated, the next logical step is a study of those things which may limit ability to generate on that particular site. These would be primarily the quantity of water available for condensing purposes and the possibility of delivering the required amount of fuel.

If the water and fuel supply appear adequate, the area of the site and area and cubical content of buildings come into consideration.

Finally, the adequacy of existing switching equipment should be given attention. Any scheme which will permit the use of existing equipment would naturally stand a better chance of financial justification than one which required complete rebuilding of the electrical end of the plant.

With such possible limitations clearly evaluated, the most important decision in the average case and that on which all else may be said to hang, is whether the boilers are to be retained or scrapped. If they are to be retained, the operating steam pressure is limited to its earlier value except in those cases where a high-pressure unit is installed as an addition to existing equipment. If the boilers are to be retained, there is definite restriction of choice as to what may be done; on the other hand, there is the certainty of a smaller expenditure.

There has been much misunderstanding of the significance of high steam pressure. It happens that a very rapid improvement in the thermal efficiency of power plants has occurred during the same time that we have been stepping up steam pressures. As a result, many who are not familiar with all the details have come to assume that the first is entirely the result of the second. This is really far from a complete statement of the facts.

During the same interval, we have increased the boiler room efficiency from values falling between 70 and 78 per cent up to values falling between 84 and 89. A change from 78 to 88 represents a fuel saving of almost 13 per cent.

We have also adopted the regenerative cycle of operation, that is, heating of the feedwater in steps by means of steam bled from the turbine. This represents a saving varying from 5 per cent to 11 per cent when referred to the coal pile.

It should also be noted that we have, in addition, increased the total steam temperature. In a period of about 15 yr., we have gone from a total temperature of about 600 deg. F. to a total temperature of about 725 deg. F. This change of temperature is equivalent to a thermal improvement of between 4 and 5 per cent for the plant as a whole. During all this time, the design of the steam turbine itself has been so improved as to result in a material reduction in heat consumption at

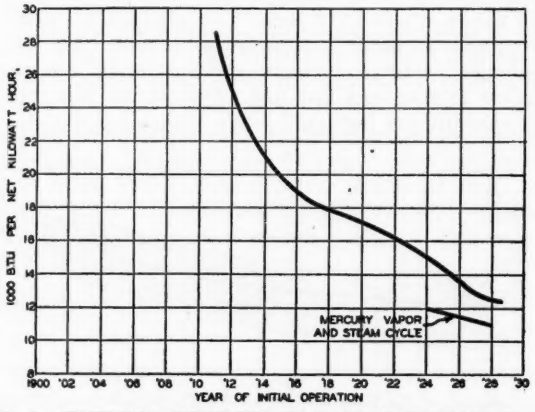


FIG. 6. THERMAL ECONOMY OF PLANTS OPERATING ON 50-60 PER CENT ANNUAL LOAD FACTOR

any given pressure, temperature and vacuum. In the rehabilitation of a station, it may be possible to do much that will result in improvement of the thermal efficiency even though the original steam pressure must be retained.

With respect to the use of higher steam pressure, the decision is not entirely confined to its effect upon the thermal efficiency because increased capacity can be obtained in this way through the use of comparatively small high-pressure turbines discharging into the old turbines, utilizing the old condensers; therefore, while the boiler room investment would necessarily be high, this may be balanced by a comparatively small turbine room investment. The use of the old generators would also, in general, make it possible to use the old switching equipment, although there would naturally have to be additions to take care of the generators of the new high-pressure turbines.

Thus far, the majority of cases of rehabilitation have fallen in the class in which the old boilers are retained,

thus accepting the limitations set by the original steam pressure. At present, these are the more interesting and probably the more important.

In such cases, the following methods of attack are available:

1. The boiler room efficiency may be greatly improved without materially increasing the steam generating capacity. This can be done by the use of more modern fuel burning equipment of one sort or another, by the addition of economizers or preheaters or both, and occasionally by improved baffling of the boilers.

2. The boiler room efficiency may be greatly improved and, at the same time, the steam generating capacity may be increased to a very great extent. It is not at all impossible to double or more than double the steam output of an old boiler room by using improved

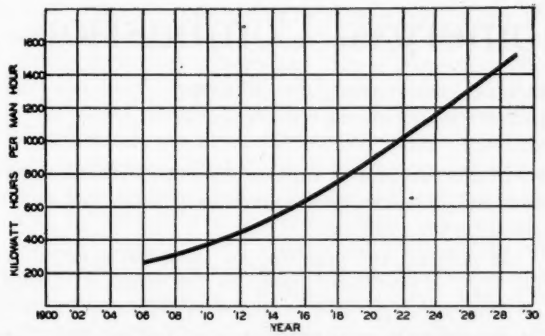


FIG. 7. KILOWATT-HOUR GENERATED PER MAN HOUR

combustion equipment of greater fuel burning capacity, while at the same time bettering the boiler room thermal efficiency through the use of economizers or air preheaters or both. It will generally be found advisable to use a certain amount of furnace wall cooling such extreme cases so as to gain the increased output most easily and so as to hold in check the tendency toward increased furnace maintenance. In this connection, it should be noted that it is frequently possible to obtain greatly increased furnace volume, as by ignoring existing floor levels and by utilizing modern ash handling equipment which requires small height for its installation.

3. The turbine room efficiency may be increased by raising the steam temperature. Naturally, this will involve more superheater surface or at least differently located surface. In most cases, the use of some sort of radiant superheater in series with the older superheaters will be found advantageous but a careful study of pressure drop through superheaters and connections must always be made. This is of particular importance when the steaming capacity of the boilers is also increased. The adoption of higher superheat will usually involve minor rebuilding of the high-pressure end of the turbine and in some cases major rebuilding of that end.

4. Turbine room efficiency and capacity may be increased by several different methods. The most obvious, but also usually the most expensive, is by the installation of new, larger and more efficient turbines taking steam at higher temperature from a boiler room of increased steaming capacity. When this method is adopted it becomes comparatively easy to introduce regenerative feed heating because the new turbine casings will be supplied with bleeder outlets. The improvement of thermal efficiency obtainable from regenerative heating can therefore be obtained readily. Larger condensers or additions to existing condensers may have to be provided. The old electrical switchgear can sometimes be used by adopting a double winding on the generators so that the capacity per switch is held within the old limitations.

A less obvious but very effective method of obtaining increased capacity and efficiency is found in the compounding of old turbines with new turbines. At first glance, it would appear as though this would be impossible without raising the steam pressure but this is not the case. Two old turbines may be rebuilt to receive steam at lower pressure and temperature than they did before and thus to serve as low-pressure elements to a single new turbine taking steam at boiler pressure. In such cases, the extent to which regenerative heating of feed can be obtained will depend upon the design of the casings of the original turbines; naturally, the new turbine can be designed for bleeder nozzles and the exhaust connection between it and the old units can be tapped for feed heating. This general method can be made to yield an increased generating capacity of at least 50 per cent and a marked improvement of over-all efficiency as well.

Even when neither of the methods just considered is available, it is still frequently possible to obtain increased output by the rebuilding of old turbines and generators.

5. Even though it prove economically undesirable

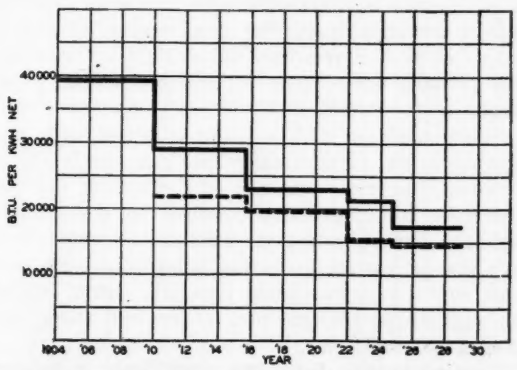


FIG. 8. THE EFFECT OF ADDITIONS TO GENERATING CAPACITY ON THERMAL ECONOMY OF A REPRESENTATIVE GENERATING SYSTEM

to replace or to rebuild the old turbines, it is still frequently possible to obtain marked thermal improvement in addition to that which can be obtained in the boiler room. This can be done through modification of the auxiliary power supply and the heat balance of the station. One is inclined to think of regenerative feed heating as necessarily tied to the bleeding of each main unit. In fact, it is obtained to a certain extent whenever that steam which is used for heating feedwater has done useful work before being used for that purpose. From the thermal standpoint, it is most perfectly obtained when the steam has done the greatest amount of work before being used for heating and when the heating is done in the greatest number of temperature steps. Practically two or at the most three steps will ordinarily prove economically the best with moderate

steam pressures such as one would expect in plants now being rehabilitated.

Designing Original Plant with Rehabilitation as Possibility

It is true that some executive engineers do not accept rehabilitation as economically justifiable in their own systems; therefore, it is not legitimate in all cases to predicate original station design on the assumption that rehabilitation will be a necessary part of the history of the plant. Such rebuilding, to a greater or lesser extent, however, appears to be becoming more general than it once was and the history of any given system with respect to such practices should be given serious study when designing new plants for that particular system. If it has been one in which rehabilitation has been found economically desirable, it is obviously the part of wisdom to design rather generously with respect to ground area, floor area, cubical contents and clearances, so that if and when rehabilitation becomes necessary there may be the greatest degree of flexibility. It is patent that this consideration should not be used to the disadvantage of the present in order to obtain a questionable advantage in the future. But, in the design of any station, many decisions must be made on very intangible grounds; the proper values cannot be determined by calculation and the decision must in the end rest upon personal opinion or arbitrary choice. In such cases, it is well to consider the effect of such decisions upon the possibilities of future rehabilitation.

Commercial Uses of Submerged Combustion

Early History and Present Commercial Possibilities of Burners Which Consume Fuel in Direct Contact with Water or Other Liquid

OBVIOUS LOSSES which cannot be eliminated from the conventional boiler and furnace led to early experimentation with submerged burners in which the flame is introduced below the surface of the liquid and heat transfer takes place by direct contact of the liquid and products of combustion.

Aside from any thermodynamic advantages, such a system eliminates the usual large and bulky furnace and boiler wherein heat transfer takes place through metal surfaces although it has the disadvantage of requiring equipment to compress the fuel and air for combustion to a pressure above that maintained in the pressure vessel.

Steam made in such a boiler is mixed with almost an equal weight of noncondensable gas, mostly CO_2 and nitrogen. Naturally, the use of such vapor for power generation is of necessity confined to noncondensing machines. In expanding the mixture, according to Dalton's law of partial pressures, behaves as superheated steam down to atmospheric pressure, steam condensation with 50 per cent gas and 50 per cent steam taking place at about 175 deg. F.

Applied in this field, the most likely development lies in the application of special steels and alloys for use in gas turbines or engines designed to work at pressures and temperatures approaching those met with in Diesel engine practice.

At present, the practical use of steam generators of this type is confined largely to the chemical industry for concentrating and evaporating solutions, although the development of a practical unit for hot water heating systems is a considerable step forward while the developments of indirect methods which allow the generation of pure steam free from gases opens up possibilities in the condensing field.

One practical application that has been suggested is in connection with sewerage plants, that is evaporating the water from activated sludge and using the steam so generated for the operation of turbines. The same application has been proposed for the disposal of sulphite liquors in paper mills.

Development Covers Almost 50 Yr.

Practical development of burners of this type covers almost half a century extending from the patents of Collier in 1887 to the most recent patents of C. Featherstone Hammond and William Shackleton to whom we

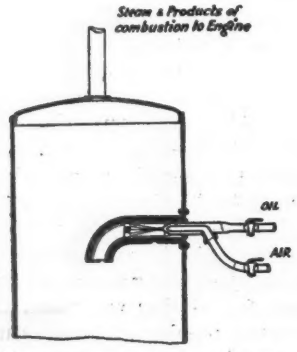


FIG. 1. BURNER PATENTED BY COLLIER IN 1887

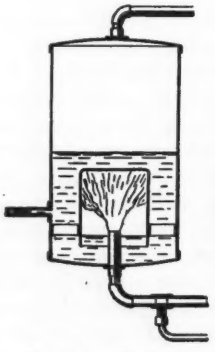


FIG. 2. BRUNLER BURNER OF 1893

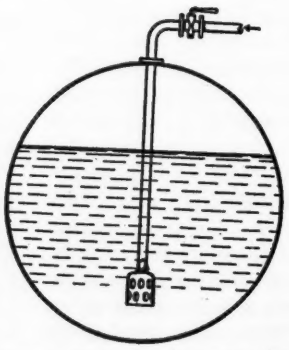


FIG. 3. DESIGN OF SCHOLLEN AND VILLENEUVE IN 1894

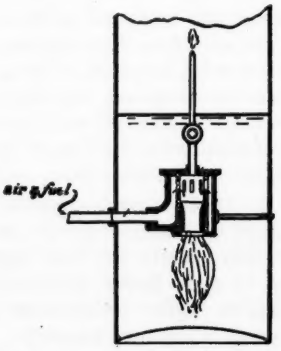


FIG. 4. BRUNLER COMBUSTION CHAMBER DESIGN, 1898

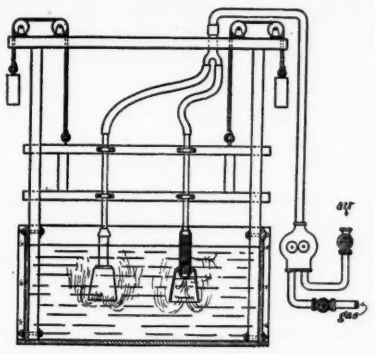


FIG. 5. THE FIRST VELOCITY TUBE DESIGN TO PREVENT BACK-FIRING, SMETHURST 1901

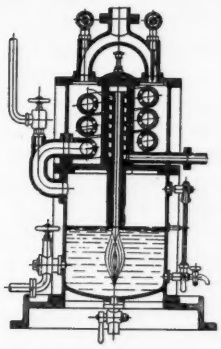


FIG. 6. HAUPTMANN BURNER OF 1906 WITH PREHEATER AND SUPERHEATER

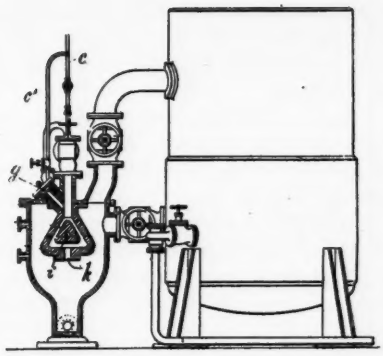


FIG. 7. PRESENT BRUNLER STEAM GENERATOR WITH BURNER AND CONNECTIONS

are indebted for much of the material covering the historical development.

Collier's burner shown in Fig. 1 consisted of a submerged blow pipe and was the best of the early design although constructed with an inadequate mixing and combustion chamber. One of Brunler's early attempts is shown in Fig. 2. It is not a true submerged burner, as the flame is not in contact with the water but it is an interesting step in development.

In 1894 Schollen and Villeneuve brought out the perforated bell design shown in Fig. 3 which was closely followed by a Brunler's design shown in Fig. 4 employing a somewhat similar submerged chamber and an ignition device. Smethurst's burner, shown in Fig. 5 was used in the chemical industry for some time and is probably the first attempt to use high velocity tubes to prevent back-firing. No combustion space was provided, however.

Hauptmann's burner, Fig. 6, employed a combustion chamber, high velocity tubes and a superheater. Primary combustion took place in the helical slot around the burner and the products of combustion flowed down the tube to the submerged flame. Steam and products of combustion passed through coils and issuing from perforations were superheated by contact with the outside of the hot combustion tube.

The 1907 design of Brunler also employed a superheater, a small part of the flame being bypassed to the steam exit pipe. The latest Brunler burner and complete steam generator is shown in Fig. 7. Fuel enters the burner at c and the flame issues from the submerged opening k. Chamber g is the ignition device. A refractory tube is first heated to redness and a small stream of fuel allowed to enter through c', and burn until the bridge piece i is heated sufficiently to cause ignition. The main fuel stream is then turned on.

Hammond Burner Now in Practical Use

In Fig. 8A, the construction and design of the Hammond burner for gas is illustrated. The combustion chamber 3 is constructed of highly refractory material supported so as to allow free expansion and contraction. Air enters at 20 and flows as indicated by the arrows. Gas enters at 26, flows through a series of chambers, mixes with the air and after thorough mixings, by flowing through alternate laminations of metal and gauze, passes through the high velocity tube to the combustion chamber. Ignition is started by the spark plug 41 and combustion can be observed through the glass 34.

Practical application of this burner to a hot-water heating system unit is shown in Fig. 8B. The burner 8 is installed as shown with the exit end in the circular chamber or air lift foot piece 10. Water from the main tank 27 flows down to the circulator tube and is carried up to the head tank 17 by the air lift action of the steam and products of combustion. From this tank, the heated water flows through the outlet 16 to the hot-water radiators and, returning, enters at 19, cascading down to the chamber 27 over the deflectors 21. Gases of combustion and steam descend around the riser pipe as indicated by arrows, pass up under the deflectors, counter current to the entering water, where the steam is condensed and the gases are cooled to the lowest possible temperature before leaving by way of the vent 13.

Efficiency depends upon the heat loss in the saturated exit gases. If the maximum attainable efficiency, reached when the returns are at atmospheric tempera-

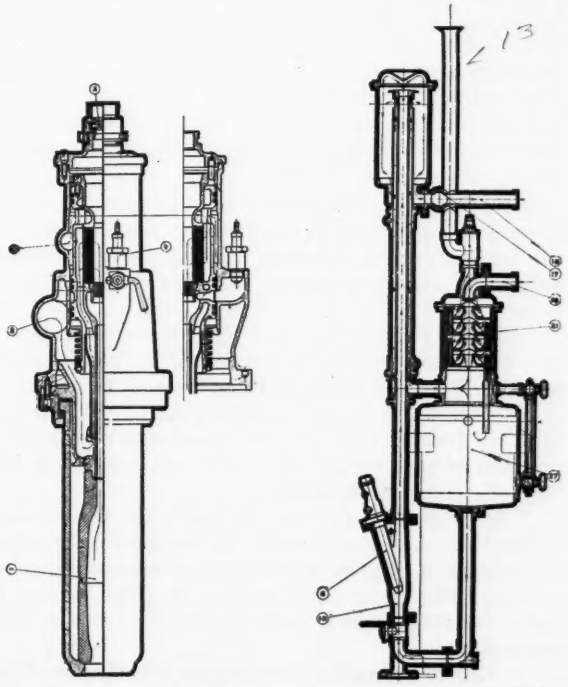


FIG. 8. A. THE HAMMOND SUBMERGED FLAME BURNER FOR GAS. B. APPLICATION OF THE BURNER TO A HAMMOND CENTRAL HEATING UNIT

ture, is considered as 100 per cent, the loss at 86 deg. F. will be about 1.75 per cent; at 104 deg. F., 2.91 per cent; at 122 deg. F., 5 per cent and at 140 deg. F. about 10 per cent.

Such efficiencies are, of course, not approached in other heating systems. Although in modern large stations boiler efficiencies of 90 per cent and over have been and are being obtained, the efficiency of the average plant is much lower and probably ranges down to 10 or 15 per cent in poorly operated heating boilers.

Pressures in steam generators with submerged burners are considerably higher than those of usual steam boilers operating at equal temperatures. For instance, burning coal gas of a certain composition and generating 10.43 lb. of steam at 482 deg. F. per pound of gas would give 10.43 lb. of steam and 9 lb. of non-condensable gas with a total pressure equal to the sum of the partial pressures of the steam and gas at 482 deg. F., that is 450 plus 282 or 732 lb. per sq. in. abs.

Practically any fuel such as produces coal or water, gas, carbon monoxide, hydrogen oils and pulverized coals, can be burned in this manner. Combustion is controlled by a single handwheel which regulates both the air and fuel so as to maintain the definite proportions needed for complete combustion through the entire range of the burner.

In the indirect method, applicable where the products of combustion are not desirable in the steam or vapor produced, the Hammond system utilizes an indirect method in which the burner operates in a bath of metal such as lead and the heat is transferred from this intermediate medium to the liquid to be heated in some form of heat exchanger.

A. E. C. Organizes Committees

ORGANIZATION FOR 1929 of more than a score of committees to work with Congress and the Federal administration in shaping public policies involving vast engineering operations is announced by the American Engineering Council, 29 West 39th St., New York City. Communications, flood control, safety of dams, water resources and Government reorganization are among the chief problems to be studied.

At a meeting of the Council's Administrative Board to be held in Washington in October, these committees will submit reports reflecting the engineering attitude toward legislation arising at the next session of Congress.

With an engineer in the White House and with a growing representation of engineers in public posts, national, state and municipal, the Council, according to an announcement by its president, Arthur W. Berresford, has framed what is believed to be the most helpful program of coöperation with public agencies in the history of American engineering.

The result, he adds, should enable the Government to function more intelligently in engineering projects requiring annually the expenditure of many millions of dollars. Mississippi flood control he cited as one of many situations which need clarification by the civil engineer.

D. Robert Yarnall of Philadelphia is chairman of the Public Affairs Committee. Public questions affecting engineers generally will come before this Committee, other members of which have been chosen as follows: J. L. Hamilton, St. Louis; John Lyle Harrington, Kansas City, Mo.; H. A. Kidder, New York City; W. S. Lee, Charlotte, N. C.; R. C. Marshall, Jr., Chicago; Charles Penrose, Philadelphia; R. F. Schuchardt, Chicago; C. E. Skinner, East Pittsburgh, Pa.; Max Toltz, St. Paul, Minn.; Edwin F. Wendt, Washington, D. C.

New Committee on Communications has been named to study proposed legislation for Federal supervision of such means of communicaton as radio, telephone, and telegraph. This Committee, headed by Edwin F. Wendt of Washington, will study fundamental questions raised by the Watson and Couzens bills. Other members are: O. H. Caldwell, New York, Federal Radio Commissioner; Dean Dexter S. Kimball, Cornell University; Frank A. Scott, Cleveland; Charles B. Hawley, Washington, D. C.

Gardner S. Williams of Ann Arbor, Mich., is chairman of a Committee on Flood Control. Mr. Williams also heads Committees on Government Reorganization and the Safety of Dams.

Chairmen of other Committees of the Council include:

Power—Farley Osgood, New York; Reforestation—William Boss, University of Minnesota; Street and Highway Safety—M. M. Fowler, Chicago; Recent Economic Changes—Dean Dexter S. Kimball, Cornell University; Engineering and Allied Technical Professions—H. C. Morris, Washington; Regional Activities, and Membership and Representation—O. H. Koch, Dallas, Tex.; Program of Research—Dr. Harrison E. Howe, Washington; Man-Hour Information, and Constitution and By-Laws—L. P. Alford, New York; Patents—Edwin J. Prindle, New York; National Hydraulic Laboratory—Farley Osgood, New York; Washington-Potomac Canal—D. H. Sawyer, Washington; Finance—John H. Finney, Washington; Representation—A. W. Berresford, New York.

Census Suggestions Requested

IN PREPARING the schedule for industries, the advisory committee of manufacturers, which is assisting the Census Bureau, is seeking suggestions and coöperation from those engaged in industry. The object is to have data collected and so tabulated that the information will be of the greatest use possible to industry.

Subjects covered by the 1927 schedule were: Description of establishment; character of industry; time in operation; persons engaged; salaries, wages and materials; products; power used; coal consumed. The committee desires the widest possible opinion from organizations, associations and manufacturers as to questions to be formulated, scope of the census, data desirable and practicability of supplying the information desired. The aim is to secure facts which will aid in meeting problems of production and distribution and in shaping production and sales policies.

As the printing of the schedules must begin soon so that they may be ready well in advance of the enumeration, the committee urges that suggestions be sent promptly to Thomas W. Howard, secretary, 1615 H. St., N. W., Washington, D. C.

Six Years Progress in Power Plant Design

represented by

NEW 75,000-KW. CAHOKIA UNIT

Novel condenser arrangement, double winding generator and improved boiler construction allow doubling of capacity in same space

ON OCTOBER 17, 1923, Unit No. 1 at Cahokia Station of the Union Electric Light & Power Co. was put on the line serving the St. Louis district with electric power. The station* was a sensational advance in central station design and represented the most modern practice at that time. In the first section, eight 18,010-sq. ft. boilers fired by pulverized coal from a central system supplied steam at 325 lb. gage, 725 deg. F. to two 35,000-kw. turbines which were bled at one stage for feedwater heating.

So rapidly has the power plant field moved forward, however, that within six years it has been possible to replace one of the 35,000-kw. turbines and generators with one rated at 75,000 kw. The new turbine, with over twice the capacity of the old one, is installed in the same space, on practically the same foundation, uses practically the same sized condenser and is supplied by steam by the same boilers rebuilt so as to generate the additional steam necessary for the larger machine.

From beginning to end, the new installation is a record of progress; progress that includes boiler, turbine, condenser and generator design. Probably the most remarkable feature is the rebuilding of the furnaces to generate twice as much steam with the same boilers; the culmination of six years practical experience and experimentation with furnace construction by E. H. Tenney, chief engineer of power plants.

Undoubtedly the most unique feature is the use of two expansion joints with the condenser and the method of supporting the condenser independently of the turbine foundation, while the double winding generator, which allows the use of practically the same switching equipment and structure, and improved condenser design, which handles practically twice the amount of steam with but a slight increase in surface, have both helped materially in making the installation possible.

*See Power Plant Engineering April 1, 1924, page 365.

Condenser Arrangement

Safe loading of the piling upon which Cahokia is built prohibited the installation of the larger turbine, generator and condenser on the old foundation. In order to bring the weight on the turbine foundation within safe limits, the novel construction shown in Fig. 1 is used, the Worthington condenser (and added weight of circulating water) is supported independ-

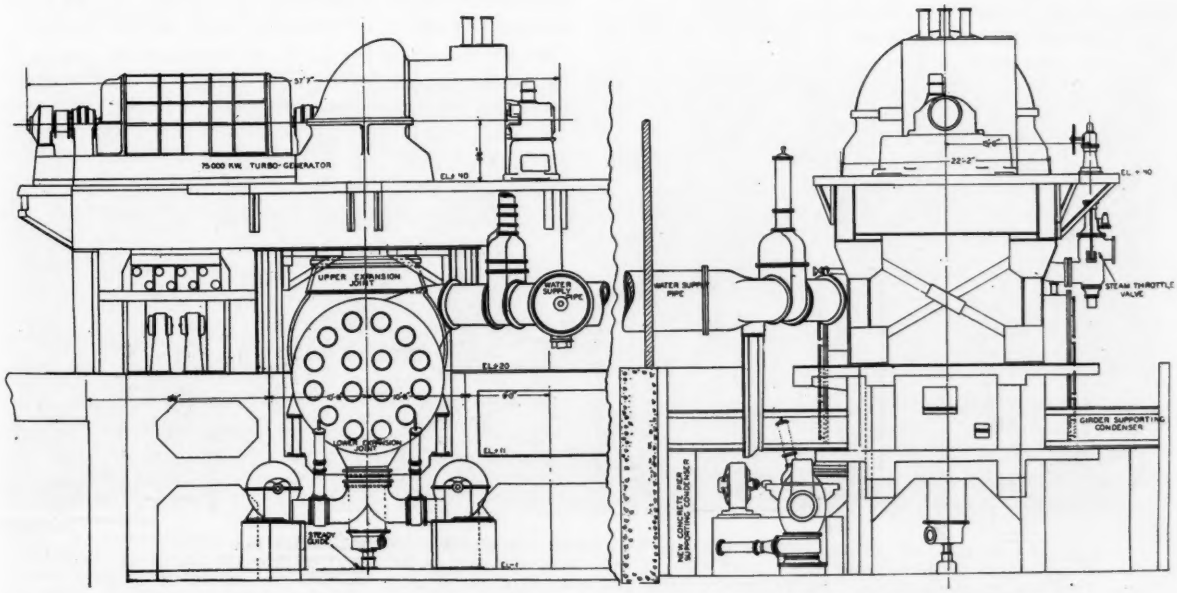


FIG. 1. GENERAL ARRANGEMENT DRAWINGS OF THE NEW 75,000-KW. UNIT AT CAHOKIA

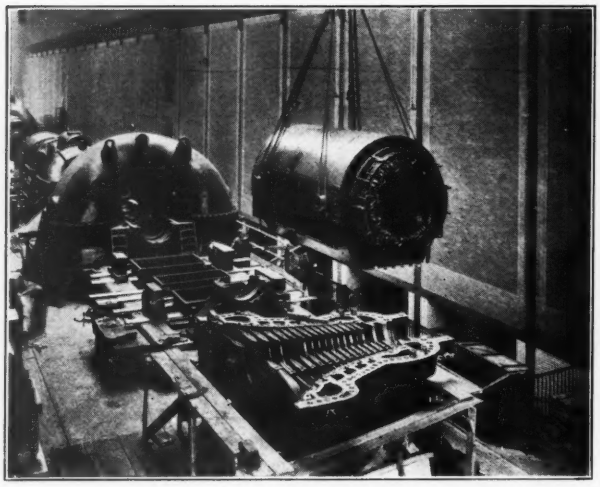


FIG. 2. PLACING THE STATOR OF THE 75,000-KW. GENERATOR ON THE FOUNDATION

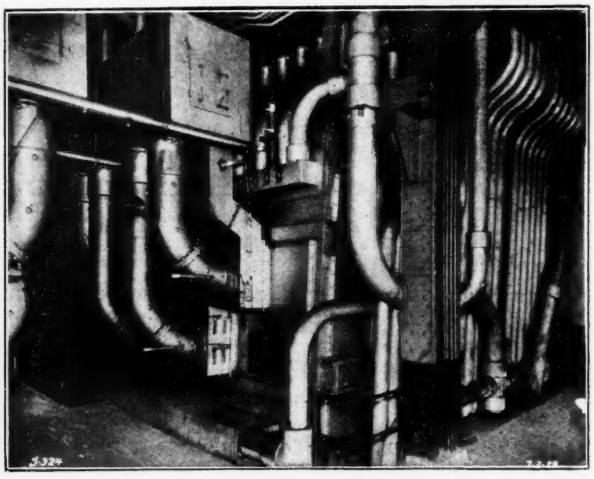


FIG. 3. NO. 1 BOILER AFTER RECONSTRUCTION SHOWING THE FOUR BURNERS, AIR DUCTS AND CIRCULATING TUBES

ently of the turbine on two transverse girders which are carried by independent piling. These girders are shown in both Figs. 1 and 8B.

Two Phillips expansion joints of equal area, one at the bottom and one at the top, are provided and allow ½-in. horizontal and 2-in. vertical movements of the shell independent of the turbine and hotwell. Expansion joints are designed for a back pressure of 5 lb. but were tested in place with the condenser under a head of 30 ft. of water.

In normal operation, under vacuum, the downward thrust of the atmosphere on the turbine exhaust casing is balanced by an equal upward thrust on the bottom of the hotwell. This load of about 393,000 lb. is carried from the hotwell to the exhaust casing and then to the exhaust casing of the turbine by nine internal vertical columns of 8-in. standard wrought iron pipe as shown in Fig. 4.

With vacuum on the turbine, these columns are under compression. With no vacuum, they are under a slight tension that is sufficient to give the 20,000 lb. minimum downward pull on the turbine specified by the General Electric Co. The remainder of the weight of the hotwell, and condensate in it, is carried by the springs shown in the drawing. The expansion joints measure 10 ft. 6 in. by 18 ft. (internally) as shown in Fig. 4, which also shows the details of the joint seal consisting of a rubber ring held in place by an almost continuous line of pressure plates and sealed by water.

The old two-pass condenser, also a Worthington, with a total condensing surface of 53,000 sq. ft., had 10,800 ⅞-in. O. D. tubes packed at both ends and arranged as shown in Fig. 6. The new condenser, also two-pass, has a total condensing surface of 60,000 sq. ft., with 13,100 ⅞-in. O. D. tubes rolled at the outlet end, packed at the inlet end and arranged as shown in Fig. 7.

Turbine and Generator

At full load, the new turbine will be supplied with 825,000 lb. per hr. of steam at the throttle and of this amount about 170,300 lb. will be bled in two stages leaving 654,700 lb. of steam per hour for the condenser. This amounts to about 6.1 lb. of steam per hr. per sq. ft. of condensing surface. Circulating water is supplied by 36-in. Worthington pumps driven by two-speed

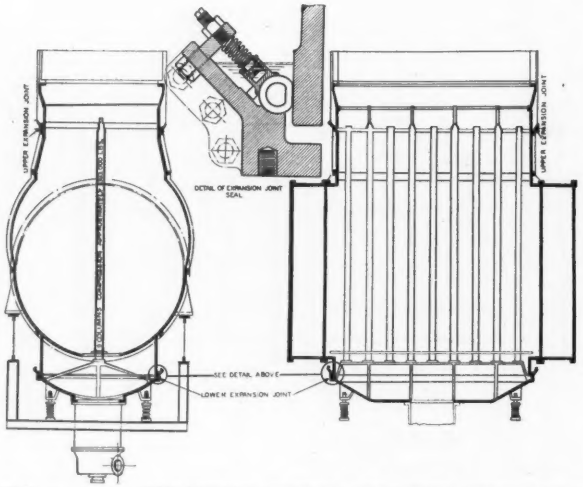


FIG. 4. TWO EXPANSION JOINTS ARE USED WITH THE CONDENSER, ONE BELOW AND ONE ABOVE THE SHELL

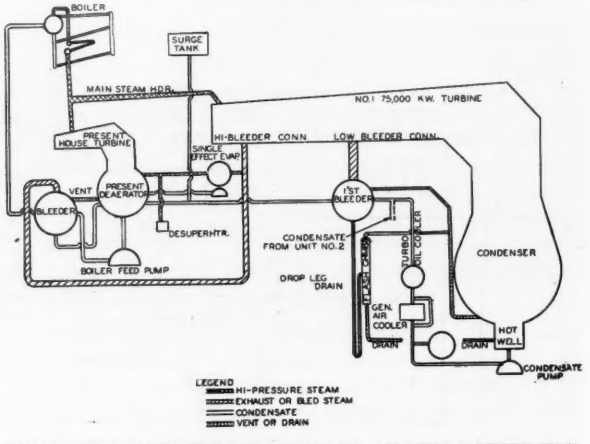


FIG. 5. THE NEW TURBINE IS BLED AT TWO POINTS FOR FEEDWATER HEATING

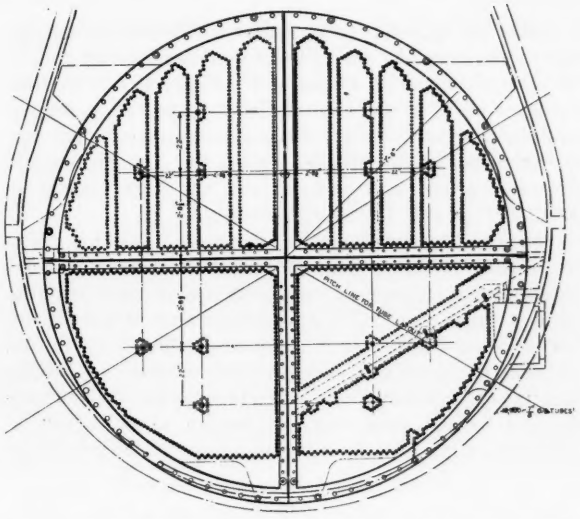


FIG. 6. TUBE SHEET LAYOUT OF THE OLD 53,000-SQ. FT. CONDENSER INSTALLED IN 1923

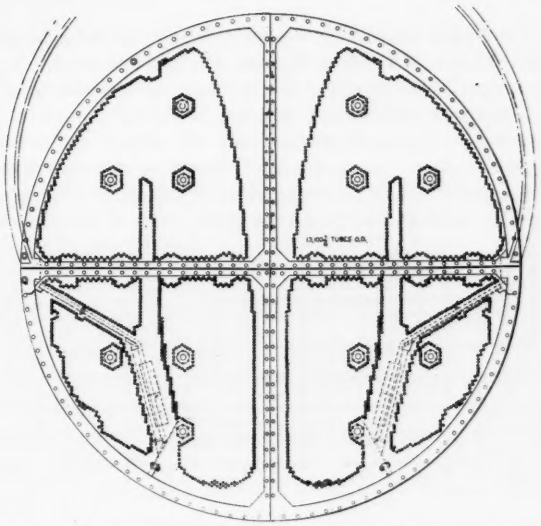


FIG. 7. TUBE SHEET LAYOUT OF THE NEW 60,000-SQ. FT. CONDENSER WHICH CONDENSES TWICE AS MUCH STEAM AS THE OLD ONE

2300-v. motors. The maximum capacity is 70,000 g.p.m. A rotative dry vacuum pump is used.

In the original installation but one stage of extraction heating was employed. In order to take advantage of the increased economy of higher feedwater temperatures, the heat balance diagram of the new unit has been modified so as to heat the condensate from the 35,000-kw. Unit No. 2 from about 150 to 320 deg. F. This additional condensate enters before the low-pressure heater as shown in Fig. 5.

Because of this, approximately 179,000 lb. of steam is bled from the new turbine at maximum load instead of about 132,300 lb. which would be required if the unit were heating only its own condensate. At a flow of 825,000 lb. of 315 lb. gage, 725 deg. F. steam to the throttle and 1.5 in. vacuum and heating the condensate of No. 2 unit, the following conditions will prevail:

1. Leaving hotwell ..... 91.8 deg. F.
2. Leaving generator air cooler variable
3. Leaving oil cooler.....110.0 deg. F. (From Unit No. 2 359,000 lb. at 150 deg. F.)
4. To low-pressure heater....123.4 deg. F. (Bled to low-pressure heater 56,000 lb. at 8.48 abs. press. and 1112.1 B.t.u. per lb.)
5. From low-pressure heater.173.2 deg. F. (House turbine exhaust 41,700 lb. to deaerator at 1202 B.t.u. per lb.)
6. Leaving deaerator ..... 213 deg. F. (Bled to high-pressure heater 114,300 lb. per hr. at 95.3 lb. abs. press. and 1282 B.t.u. per lb.)
7. Leave high-pressure heater (final) .....314.4 deg. F.
8. Kw. load ..... 76,355 kw.

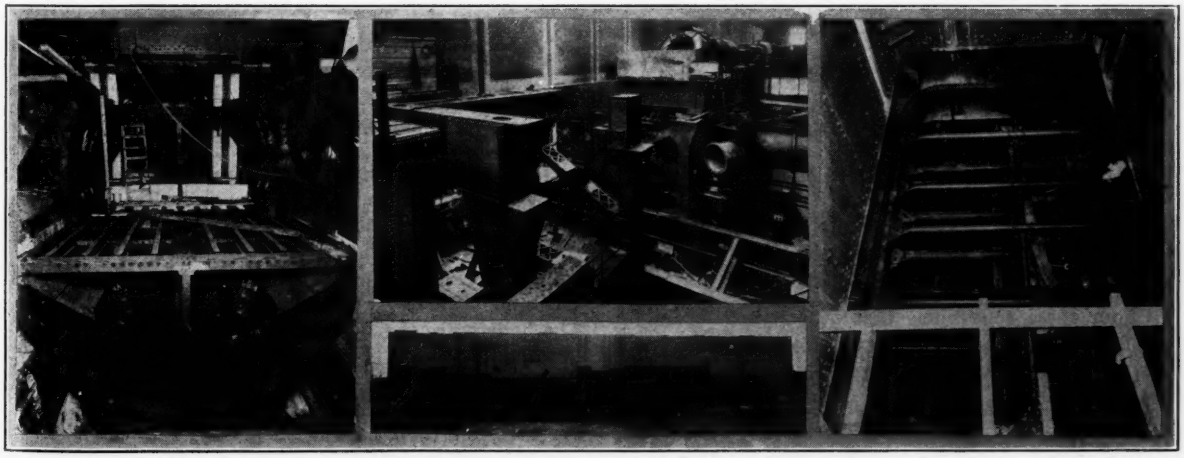


FIG. 8. A. CONDENSER UNDER ERECTION SHOWING THE LOWER EXPANSION JOINT IN PLACE. B. TURBINE FOUNDATION SHOWING SPACE FOR GIRDER ILLUSTRATED IN C AND THE TWO TRANSVERSE GIRDERS WHICH SUPPORT THE CONDENSER. C. ONE OF THE SIDE GIRDERS FOR THE FOUNDATION. D. LOOKING DOWN INTO THE CONDENSER DURING ERECTION. (ONE SECTION OF THE UPPER EXPANSION JOINT IS IN PLACE AT THE RIGHT.) THE RIGHT.)

Drips are cascaded; a single effect Griscom-Russell evaporator and Griscom-Russell heaters are used. The feedwater is deaerated in a Cochrane open heater using the exhaust steam from the house turbine.

Steam consumption per unit of output on a non extraction basis is considerably lower on the new unit, a General Electric 17-stage, single-cylinder, 1800-r.p.m. machine bled at the 8 and 14-stage, than it was on the

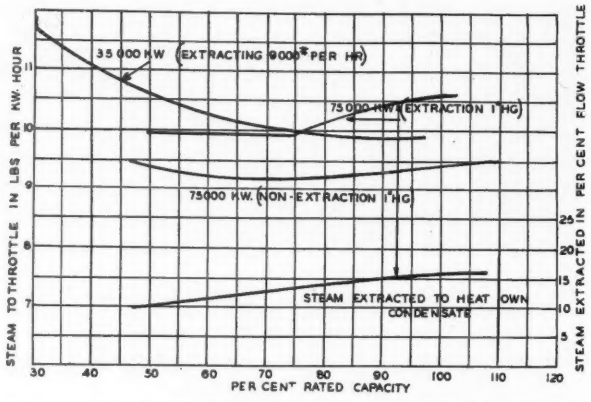

35 000 KW (EXTRACTING 9000# PER HR)
75 000 KW (EXTRACTION 1" HG)
75000 KW. (NON-EXTRACTION 1" HG)
STEAM EXTRACTED TO HEAT OWN CONDENSATE
STEAM TO THROTTLE IN LBS PER KW. HOUR
STEAM EXTRACTED IN PER CENT FLOW THROTTLE
PER CENT RATED CAPACITY
30 40 50 60 70 80 90 100 110 120
11 10 9 8 7
25 20 15 10 5

FIG. 9. STEAM CONSUMPTION OF THE NEW TURBINE IS CONSIDERABLY LOWER THAN THAT OF THE OLD

old. Steam consumption guarantees of the 75,000-kw. unit at 1 in. back pressure on a non-extraction basis are:

Load Kw.	Lb. Steam per Kw-Hr.
35,000	9.39
52,500	9.18
65,000	9.25
75,000	9.38

On the old unit the steam consumption when bleeding 9000 lb. per hr. was 30,800 lb. (to roll) plus 8.83 lb. per kw-hr. Steam consumption of both units plotted as lb. per kw-hr. are shown on Fig. 9. The steam extracted for feedwater heating as shown in Fig. 9 is that which would be required for heating the condensate of the 75,000-kw. unit only and does not include that needed for heating the condensate from No. 2 unit.

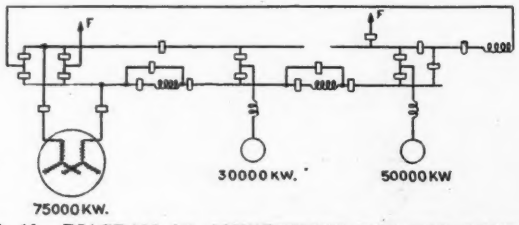


FIG. 10. DIAGRAM OF CONNECTIONS FOR THE DOUBLE WINDING GENERATOR

Under these conditions, that is, bleeding steam for heating on the basis of the curves shown in Fig. 9, the expected performance at 1 in. hg. from which the curves were drawn is:

Steam flow lb. per hr.	Load Kw.	Extracted lb. per hr.	Final temp. Deg. F.
825,000	77,600	132,300	315
700,000	67,365	103,700	304
545,000	55,285	69,100	285
350,000	35,460	31,800	259

At 1 in. hg. and a steam flow of 545,000 lb. per hr. the pressure in the shell at the first bleed point will be 66.6 lb. abs. and at the second 5.95 lb. abs. with heat contents of 1238, 1084.5 and 988.8 respectively for the first bleed point, second bleed point and exhaust. At a steam flow of 825,000 lb. per hr. the pressures would increase to 104 and 8.84 lb. and the heat content to 1282, 1111.5 and 1002.5 respectively.

Figure 10 shows how the 60-cycle, 83,333-kv-a., 13.8-kv. double winding generator will be connected. By utilizing the emergency bus from the original installation, a large part of the switchgear as originally installed is used although with some sacrifice of flexibility. Feeders are arranged with selector switches so that the amount of load may be adjusted to some extent by transferring feeders from one bus section to the other, to distribute the load on the two windings of the generator.

Boilers

In the boiler room the first four boiler furnaces have been rebuilt from the type shown in Fig. 11A with

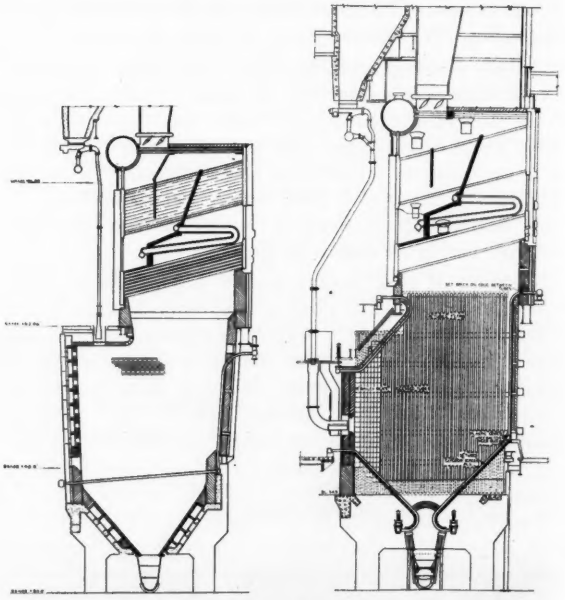


FIG. 11. A. BOILER SECTION OF THE ORIGINAL FURNACES WITH REFRACTORY WALLS AND VERTICAL BURNERS. B. SECTION OF THE REBUILT FURNACES WITH WATER COOLED WALLS AND HORIZONTAL BURNERS

refractory walls, water screens, air-cooled ashpits and 10 vertical burners to that shown in Fig. 11B with water-cooled walls and ashpit and 4 Bailey-Tenney horizontal burners.

Each boiler has 18,010 sq. ft. of boiler heating surface and 4070 sq. ft. of interdeck superheater surface. The boilers are the Babcock & Wilcox cross-drum type, 20 tubes high and 38 tubes wide equipped with 18 Diamond soot blowers, Copes feedwater regulators and Bailey combustion control.

In the old furnaces, the combustion volume above the water screen was 11,440 cu. ft. In the new furnaces, the total combustion volume is 1456 cu. ft. including the ashpit. A total of 2147 sq. ft. of water-cooled walls is provided in the new units. The back and side walls are made up of 4-in. bare tubes spaced on 7-in. centers and

recessed in refractory and a strip of Bailey blocks along the side walls under the arch and adjacent to the refractory front wall. The ashpit with 394 sq. ft. of surface is made up of cast-iron blocks and the short arch of 202 sq. ft. of refractory recessed bare tubes. Pulverized coal is supplied by the central system from the original preparation house. Both the engineering and construction of the new installation and rebuilding of the boilers was planned and carried out by the engineering department of the Union Electric Light & Power Co. under the direction of E. H. Tenney, chief engineer of power plants.

Gain Effected by Feedwater Heating

MULTISTAGE EXTRACTION OFFERS DESIRABLE METHOD OF MINIMIZING HEAT CONSUMPTION OF A STATION. BY R. L. REYNOLDS

CHANGES in the operating conditions of a turbine—such as inlet pressure and temperature, exhaust pressure and number of stages of feedwater heating affect the heat gain obtainable from feedwater heating. To study these factors, a four-stage feedwater heating arrangement as in Fig. 1, will be used. In this arrangement, feedwater is pumped through four closed heaters in series, being heated in stages by steam bled from four corresponding bleeder points of the turbine. The steam

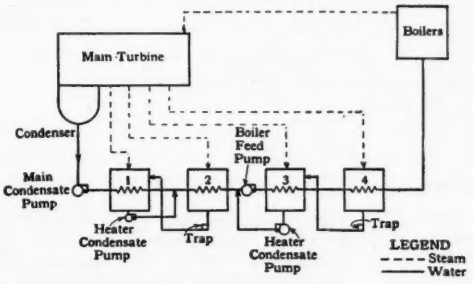


FIG. 1. DIAGRAMMATIC ARRANGEMENT OF HEATERS FOR FOUR STAGE FEEDWATER HEATING

condensed in the highest temperature heater, No. 4, is cascaded through a trap into the steam space of the No. 3 heater. To avoid pumping against the head of the boiler feed pump, the combined steam condensed in No. 3 heater is pumped into the main feed line on the condenser side of this pump.

The steam condensed in No. 2 heater is trapped back to the No. 1 heater and the combined drain from the two lower heaters is pumped into the main feed line between the two heaters. The feasibility of using a heater condensate pump on the No. 3 heater, rather than trapping this condensate back to the No. 2 heater will depend upon the size and characteristics of the particular installation.

EFFECT OF VACUUM AND FINAL FEED TEMPERATURE

Figure 2 shows that the gain obtainable with four-stage extraction increases as the final feedwater temperature increases, up to a certain point which is about 80 per cent of the saturation temperature at the turbine throttle; and that higher feedwater temperatures will result in a loss in efficiency. The slope of the curve decreases as the final feed temperature increases. When the feedwater is raised to a low final temperature, say 20 per cent of the throttle saturation temperature, the steam bled from the turbine will be at a low pressure. It will, therefore, have done a relatively large amount of its available work in the turbine and can, consequently, be utilized efficiently for feedwater heating. As the final feedwater temperature increases, steam must be bled at higher and higher pressures, with a resultant decrease in the amount of work done by that steam in the turbine until, finally, further increase in final feedwater temperature results in a reduction in efficiency, the loss in work in the turbine being more than enough to offset the gain due to the higher feedwater temperature.

The curves also show that the higher the exhaust vacuum, the greater the gain due to regenerative feedwater heating. This difference decreases as the final feedwater temperature increases, until, finally, the gain is only slightly influenced by changes in vacuum.

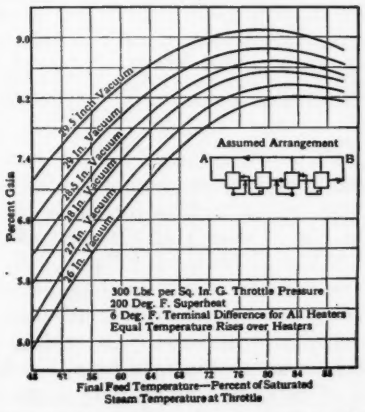


FIG. 2. INFLUENCE OF VACUUM AND FINAL FEEDWATER TEMPERATURE ON GAINS FROM FOUR STAGE FEEDWATER HEATING

When a turbine is operating with an inlet pressure other than 300 lb. per sq. in. gage, the gain obtained with four-stage extraction will vary slightly from that shown in Fig. 2. The correction to be applied for various pressures is shown in Fig. 3. These curves show that with higher pressures, more gain can be obtained with stage extraction. This means that the present trend toward higher steam pressures will also result in a trend toward greater number of stages of bleeding.

Corrections to be applied to the results obtained from the curves in Fig. 2 for various amounts of superheat at the turbine throttle are shown in Fig. 4. This curve shows that the gain due to stage feedwater heating is influenced only slightly for different degrees of inlet superheat, amounting to only one per cent for 400 deg. superheat.

[1]Turbine Engineering Dept., South Philadelphia Works. Westinghouse Elec. & Mfg. Co. From the Electric Journal.

Effect of Location of Heaters

In these calculations, the temperature rises over the heaters, when more than one heater is used, have been kept equal, or nearly equal. When this is the case, the amount of steam bled from the lowest bleeder point, at which point steam can be most economically utilized for feed heating, is smaller than at the three higher points.

Some gain in efficiency can be obtained if the bleeder pressures are so chosen that the steam bled from each point becomes equal, or nearly equal, to the steam bled from the other points. The effect of bleeding various proportions of steam to the heaters is shown in Fig. 5. Thus the best efficiency is obtained by so placing the heaters that the amounts of steam bled to the heaters are approximately the same. It also shows that, in the case where 15,560 lb. per hr. are bled to the highest heater and only 7530 lb. per hour to the lowest heater, or a ratio of more than two to one, the heat consumption of the unit is affected only 0.4 per cent, showing that considerable latitude can be used in the location of the heaters with only a slight reduction in efficiency.

Curves in Fig. 6 show that the most efficient final temperature of the feedwater is influenced by the inlet pressure of the steam, as well as by the number of stages of extraction. They also show that the most efficient final feed temperature increases quite rapidly with each additional heater up to the first four heaters. Additional points of extraction above four stages affect the efficient final temperature but slightly.

Inasmuch as the stage pressures in the turbine increase or decrease with the amounts of steam passing through the various blade groups, the saturation temperature of the steam in the turbine, consequently the final feedwater temperature, will increase or decrease with the load carried by the unit. This means that as the turbine is designed to heat the feedwater to its most efficient temperature at one load, the efficiency at other loads will be somewhat less, as the final feed temperature will be either lower or higher than the ideal. In order to obtain the best overall performance, it is necessary to choose the stage pressures in the turbine so that the average gain for all conditions of operation will be as high as possible. For the average central station turbine, the most efficient temperature should be obtained at from 75 to 80 per cent of the full-load rating. Fortunately, the curve is fairly flat for a considerable range in temperature on either side of the ideal, which means that the pressure in the turbine can be varied somewhat without appreciable loss in efficiency.

If economizers are used, it is not advisable to heat the feedwater much above 200 deg. F., as otherwise not enough heat would be extracted from the boiler flue gases and too much heat would escape up the stack. If air preheaters, or a combination of air preheaters and economizers are used, the feedwater can be heated to its most efficient temperature by steam extracted from the turbine.

It has been shown in previous calculations that the load carried by the turbine with a given amount of steam to the throttle will be less with extraction for feedwater heating than without extraction as the steam extracted from the turbine would otherwise have passed through the lower stages of the turbine and thus produced additional power. This means that in order to carry the same load, the quantity of steam required will be greater when operating with feedwater heating than straight condensing. The approximate percentage increase in throttle flow necessary to heat the feedwater to a certain temperature with one to five stages of extraction is shown in Fig. 8.

If it is desired to determine the approximate flow to the throttle when operating with three stages of extraction and heating the feedwater to 313 deg. F., for example, it would be necessary first to determine the flow without extraction and then add the amount necessary for feed heating. Assuming steam conditions of 300 lb. gage pressure and 200 deg. superheat at the throttle, exhausting at 29 in. vacuum and an internal Rankine cycle efficiency ratio of 80 per cent, the steam consumption will be 10.24 lb. per kilowatt-hour.[2] At the best-point load of 16,000 kw., the steam flow will be 16,000 × 10.24, or 163,800 lb. per hr.

When heating the feedwater to 313 deg. in three stages, the increase in steam flow to the throttle, as obtained from Fig. 8, is 13.2 per cent, making the steam flow to the throttle 163,800 × 1.132, or 185,400 lb. per hr. This percentage will vary somewhat for different throttle pressures, being slightly lower for higher pressures and slightly higher for pressures lower than 300 lb.; however, the variation in the percentage of increase in steam flow for throttle pressures between 250 and

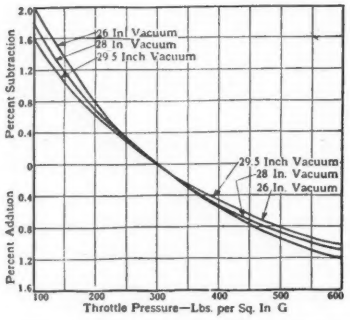


FIG. 3. CORRECTION FOR GAIN IN EFFICIENCY FROM FOUR STAGE FEEDWATER HEATING FOR VARIOUS THROTTLE PRESSURES

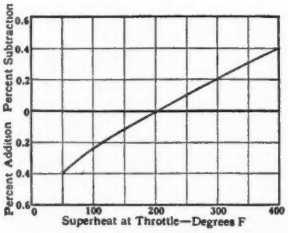


FIG. 4. SUPERHEAT CORRECTION FOR GAIN IN EFFICIENCY FROM FOUR STAGE FEEDWATER HEATING

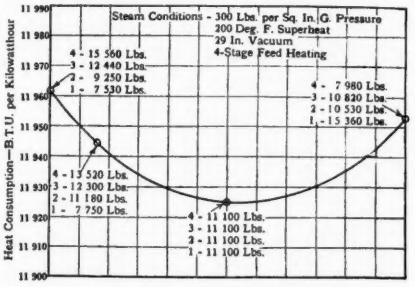

Steam Conditions - 300 Lbs. per Sq. In. G. Pressure
200 Deg. F. Superheat
29 In. Vacuum
4-Stage Feed Heating
Heat Consumption—B.T.U. per Kilowatthour
4 - 15 560 Lbs.
3 - 12 440 Lbs.
2 - 9 250 Lbs.
1 - 7 530 Lbs.
4 - 7 980 Lbs.
3 - 10 820 Lbs.
2 - 10 530 Lbs.
1 - 15 360 Lbs.
4 - 13 520 Lbs.
3 - 12 300 Lbs.
2 - 11 180 Lbs.
1 - 7 750 Lbs.
4 - 11 100 Lbs.
3 - 11 100 Lbs.
2 - 11 100 Lbs.
1 - 11 100 Lbs.

FIG. 5. SHOWING THE EFFECT OF HEATER LOCATION ON HEAT CONSUMPTION OF A STEAM TURBINE WITH FOUR STAGE HEATING

[2]See Power Plant Engineering, July 1, 1929, page 739.

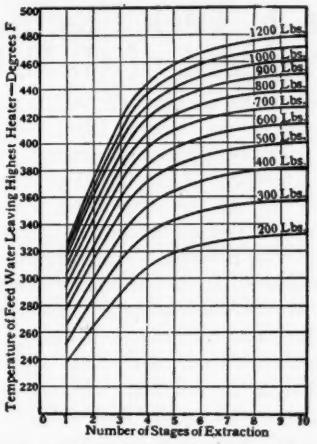


FIG. 6. FINAL FEEDWATER TEMPERATURES, GIVING MAXIMUM GAIN WITH MULTI-STAGE EXTRACTION

400 lb. is so small that it may be neglected except for the most exact studies of power plant operation.

Percentage of Steam Extracted for Feed Heating

Percentage of the steam flow to the throttle which is extracted for feed heating is shown in Fig. 9. For instance, when operating with three stages of extraction and heating the feedwater to 313 deg. F., the total steam bled will be 20.9 per cent. With a throttle flow of 185,400 lb. per hr., the steam bled will be 38,750 lb. per hr., making the flow to the condenser 146,650 lb. per hr. If the turbine were designed to bleed equal amounts of steam to each heater, the amount extracted from each bleeder point of the turbine would be approximately 9700 lb. per hr.

By using the curves of Figs. 8 and 9, the steam flow to the throttle and through the various stages of the turbine can be determined. These curves can also be used in making a rough check as to the size of condenser required. They are not limited to the turbines used in the examples but apply closely to turbines of other sizes.

Low Pressure Blading

Efficiency of the last group of reaction blading in a condensing turbine varies considerably with the amount of steam passing through it and also with the vacuum maintained in the exhaust. With 29 in. vacuum, the maximum efficiency of the exhaust group is usually obtained at about 50 to 70 per cent of the normal full load for which the turbine has been designed. For loads above and below this particular point, the efficiency of the exhaust blading decreases.

In Fig. 10 is shown the leaving loss from the last row of blades in a condensing turbine. It decreases

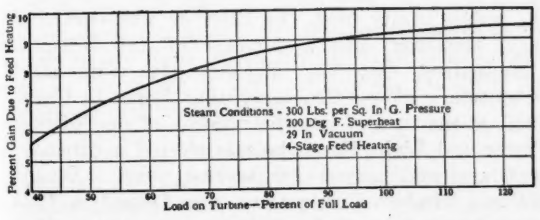

Percent Gain Due to Feed Heating
Steam Conditions - 300 Lbs. per Sq. In. G. Pressure
200 Deg. F. Superheat
29 In. Vacuum
4-Stage Feed Heating
Load on Turbine—Percent of Full Load

FIG. 7. SHOWING THE INFLUENCE OF LOAD ON THE GAIN FOUR-STAGE FEEDWATER HEATING

with increasing steam velocities through the last row of blades up to approximately 550 ft. per sec. and then increases with further increase in steam velocity. This curve is based on a turbine in which the mean blade speed of the last row is approximately 700 ft. per sec.

For turbines with higher blade speeds in the last row, the minimum leaving loss will occur at higher steam speeds, and for turbines with lower blade speeds, the steam speed giving minimum leaving loss, will be lower than 550 ft. per sec. Roughly, the point of minimum leaving loss will occur when the velocity ratio, or the ratio of blade speed to steam speed, becomes approximately 1.25.

As pointed out, for a given load, assuming equal or nearly equal stage efficiencies, a turbine operating with

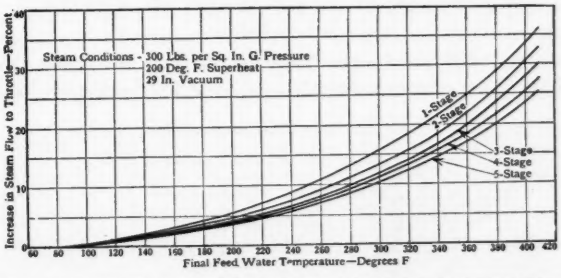


FIG. 8. WHEN EXTRACTING STEAM FOR FEEDWATER HEATING, THE TOTAL STEAM FLOW TO THE TURBINE INCREASES

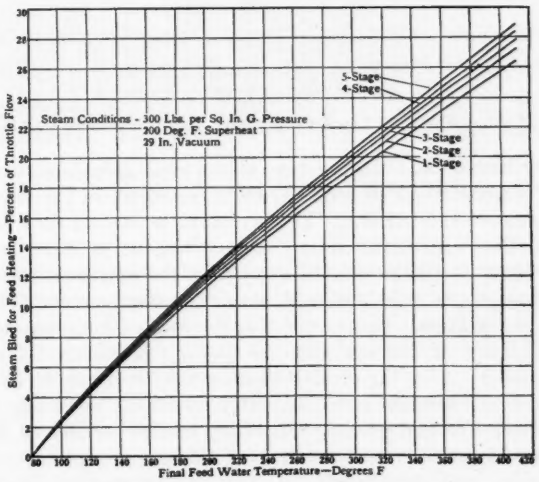


FIG. 9. CURVES SHOWING THE STEAM EXTRACTED FOR FEEDWATER HEATING AS A PERCENTAGE OF THE TOTAL STEAM FLOW TO THE THROTTLE

multi-stage feed heating will pass more steam at the throttle and less steam through the exhaust blading than a turbine operating straight condensing. As this reduction in steam flow to the condenser occurs for all loads, it will cause an improvement in efficiency of the exhaust group for higher loads, but will, at the same time, cause an impairment of efficiency at lighter loads. For a turbine that is operating above rating, i.e., where either capacity, or vacuum, or both, have been increased above normal, the improvement in efficiency of the exhaust end and consequently the additional improvement due to feed heating, occurs over a greater load range from full load down, and the impairment of efficiency

over a smaller load range from no load up. For a turbine that is operating below its rating, i.e., where either capacity or vacuum, or both, have been reduced below normal, the gain for the higher loads extends over a smaller load range and the loss for the lighter loads over a greater load range than for a machine operating at its rating. Where the turbine is operating much below its rating, as would be the case if a machine designed for 29 in. vacuum were to operate at 26 in. vacuum with normal, or less than normal, capacity, it is quite likely that there would be a loss in the efficiency of the exhaust group from feedwater heating throughout the whole load range, because the maximum efficiency of the exhaust group would occur at or above the maximum rated capacity of the machine.

Influence of Stage Extraction on Reliability of Turbine

In addition to the gain in thermal efficiency, the extraction of steam from the turbine for feedwater heating has the added advantage that a considerable amount of moisture can be removed from the steam in the lower stages of the turbine. This moisture is thrown outward by the centrifugal action of the turbine spindle, and most of it will be carried away with the extracted steam through properly designed bleeder passages to the feedwater heaters. Because of this removal of moisture, the efficiency of the low-pressure blading is materially increased. Also, the erosive wear on the blades in the low-pressure section is considerably reduced, resulting in longer life and greater reliability in this section of the turbine.

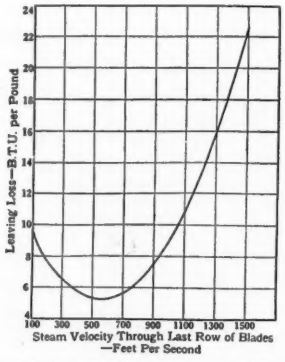


FIG. 10. LEAVING LOSS FROM THE LAST ROW OF BLADES

It can be seen that in order to obtain the maximum possible economy and reliability of a turbine the following points should be kept in mind:

1. The feedwater should be heated in as many stages as is consistent with the existing steam conditions, keeping in mind the added cost of installation and upkeep involved with the extra heaters.
2. The steam should be expanded as far as possible in the main turbine extracting for feedwater heating.
3. The feedwater should be heated to its most economical temperature, this temperature being influenced by the operating steam conditions.
4. The feedwater should be heated in increments as nearly equal as is possible with the design of the turbine used.

Operating in the manner outlined, it is obvious that multistage extracting offers a desirable means of minimizing the heat consumption of a station, especially in view of the present tendency of central station operators to employ units of larger capacity operating with extremely high pressures.

Darius E. Peck Elected Vice-President of G. E. Co.

DARIUS E. PECK, assistant manager of the law department of the General Electric Co. since 1920, was elected vice-president and general counsel of the company at a meeting of the board of directors in New York on Aug. 1. At the same time, President Gerard Swope announced the retirement of Allen H. Jackson, who has been vice-president and general counsel since 1922 and associated in the company's law department since 1902. Mr. Swope's statement follows:

"A. H. Jackson, vice-president and general counsel, has asked to be relieved, as of Aug. 1, 1929, of his responsibilities in active service. He has served the company wisely, ably and loyally and while it is with regret that we see him retire, it is with great satisfaction that we shall have him available for consultation on all matters where his experience and judgment will be of value to the company.

"D. E. Peck has been elected vice-president and general counsel of the company, effective Aug. 1, 1929."

The meeting of the board of directors was held aboard the "Viking," the new 263-ft. electric yacht of George F. Baker, Jr., a member of the board. The directors boarded the yacht at 26th St. and East River, and after the business session were guests of Mr. Baker for luncheon and a cruise along Long Island Sound.

Particular interest of the directors centers on this yacht because it was electrified by the General Electric Co. and exemplifies the first pleasure craft to be equipped with turbine electric propulsion. Lack of vibration, quiet operation and smooth running are outstanding features of this type of propulsion which make it particularly adaptable to a pleasure vessel.

The yacht, designed by Theodore D. Wells and built by the Newport News Shipbuilding and Drydock Co., has been in commission about three months. It is of the twin-screw type, each propeller being driven by a 1300 shaft-horsepower motor from electric power supplied by two turbine generators. All auxiliaries are electrically operated.

Mr. Peck, newly elected vice-president, was born at Hudson, N. Y., in 1877. He is a graduate of Williston Academy at Easthampton, Mass., and of Yale University. He studied law in the office of his father, Willard Peck, in Hudson and at the Albany Law School and was admitted to the bar in 1901. He practiced law in New York City from 1902 until 1913, when he became a member of the law department of the General Electric Co. and moved to Schenectady. Seven years later, he was named assistant manager of the department, a position he held until his promotion to vice-president and general counsel.

Mr. Peck has also had considerable experience in the public utility field. In 1915, he was elected secretary, treasurer and a director of the Schenectady Illuminating Co., the Mohawk Gas Co. and the Schenectady Power Co., succeeding James O. Carr. In 1920, at the time of the organization of the Adirondack Power and Light Corp., he was elected a director and secretary and served for several years. When the Mohawk Hudson Power Corp. was formed in 1925, he became secretary of that company, serving until April of this year. He is at present a director of the New York Power and Light Corp.

Diesel Engine Vibration Control

Explanation of How Critical Speeds Cause Destructive Vibration. Influence of Other Forces on Critical Speeds and Method of Avoiding Excessive Vibration. By Harold F. Shepherd

WHEN POWER is transmitted through the mechanism of an engine, the shafting is twisted; the connecting rod is extended or compressed and perhaps slightly bowed. Most of these members follow the simple law of strain equal to stress, without which no power can be transmitted. To every force there is an equal and opposite reaction.

Fluctuating Pressures Set Up Periodic Deformations

All machinery employing crank and piston motion is subjected to fluctuating cylinder pressures and therefore periodic elastic deformations are set up in its members. With each piston impulse these elastic deformations vary from zero to a maximum and sometimes from a positive to a negative maximum. These may, therefore, be termed "forced" vibrations.

If a downward force applied to a weight attached to the lower end of a suspended tension spring is suddenly released, vibration will set up. If a little additional force is applied, either upward or downward, at each successive movement of the weight in that direction the amplitude of motion will be greatly increased, although the frequency remains constant. The additional force causes what may be called forced impulses. If the natural or free vibrations and the forced vibrations are in synchronism, their relation is critical.

If it were not for certain damping actions, this vibrating action would continue indefinitely. The damping forces which absorb some of the energy and cause each successive swing of the weight, when vibrating freely, to be shorter although occurring in equal periods of time, are windage and hysteresis, that is, the failure of elastic bodies when deformed to extend and contract at once in absolute accord with the force acting, setting up a definite lag.

Influence of Damping Forces

Other damping forces present in machinery are friction and inertia. When the outside force applied to the system at each oscillation is just equal to the damping effect as in the case of a clock escapement, the amplitude will remain constant. If an applied force acts in unison with the natural vibrations of a system and imparts a force exceeding the damping force, the amplitude will increase and the vibrations may become dangerous; the amplitude reached may be so built up that the corresponding stress set up added to the load sustained by the machine would be so much greater than that contemplated in the design of the machine that failure of the overstressed part would occur.

Vibration Rules

Here we may set down three simple rules. Free vibrations always have an amplitude equal to or less than the single forced movement with which they originated. Vibrations which are purely forced have an amplitude that is constant and equal to the deformations of the material under the cyclical stress change. Free vibrations which are in unison with the impulses of a prime mover or power absorbing machine tend to reach amplitudes far greater than the deformation set up by any single impulse.

It may seem that synchronism between the free vibration rate of machine members and the cyclical frequency of applied impulses could rarely happen. As a matter of fact, certain machine members meet with this condition so often that vibration studies become a necessary part of the design. Where the impressed forces are not purely harmonic in their nature, as free vibrations usually are, the variable curve of force repeating itself, cycle after cycle, may be divided into component harmonies any one of which may synchronize with some speed of the machine.

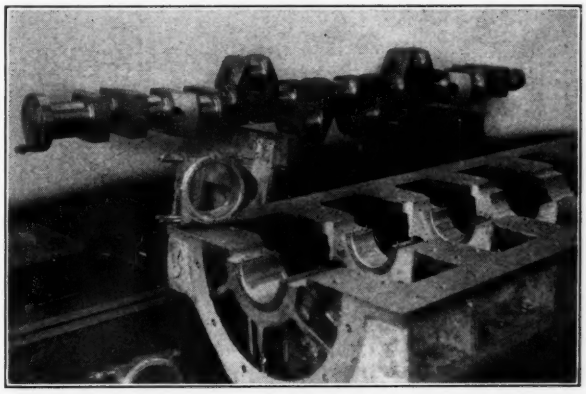


FIG. 1. MODERN DIESEL ENGINE CRANKSHAFT DESIGNED FOR GREAT TORSIONAL STIFFNESS

As there are many kinds of vibrations that may be set up in the various parts of the engine that are subject to deflection under load, there may be many critical speeds of varying degrees of importance and hence, within the operating range, a number of criticals may be due to a single cause or each may have a different cause.

Crankshaft Most Susceptible to Fracture

Vibration in the connecting rod of an engine rarely reaches the critical stage because its frequency is too high. Very long connecting rods on long stroke steam engines have developed so much vibration due to whipping action that such long rods are usually trussed. The natural frequency of stationary or marine engine frames is also usually too high to be in synchronism with the engine impulses. Under modern speeds, the crank shaft of a combustion engine is most susceptible to fracture due to critical vibrations because of the many bearings usually employed, the torsional form of

vibration and the cyclical irregularity of the twisting moment. It is rarely, if ever, affected by the whipping vibration present in turbine shafts.

Let us now consider a slender shaft of great length supported in many bearings between each of which a lever is mounted after the fashion of a crank arm with a weight on the free end representing the weight of piston, crosshead and connecting rod. The long slender shaft will then act as a torsion spring. If any one of the weights is deflected while the shaft is stationary with one end fixed, oscillation will be set up dying out as it is damped by friction of bearings, windage and other agencies. If the length of the shaft is decreased, the torsion spring becomes stiffer and the frequency of oscillation higher. If the shaft is greatly lengthened the contrary is true. If the weights on the arms are increased, oscillation will be slowed down. If they are reduced greatly, the vibrations will be much more rapid.

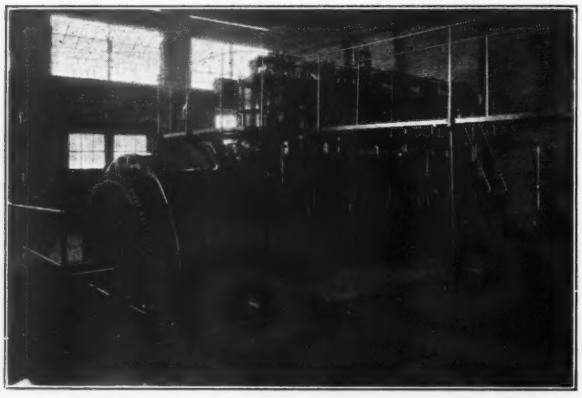


FIG. 2. DIESEL ENGINE WITH WELL SET FLYWHEEL AND GENERATOR

Increasing the shaft diameter will stiffen the spring and increase the frequency of oscillation. These statements are as true of the rotating shaft as of the stationary one.

Obviously, the greater the frequency of crank shaft vibration when released from a torsional strain, the higher the engine revolutions will have to be or the greater the number of cylinders, to reach synchronism between the power impulses and the natural frequency of the shaft. In other words, the stiffer the shaft the higher the first critical speed of importance.

Evidence of Shattering Vibration

Instruments are made for detecting the critical speeds of crank shafts but they are very expensive and not very convenient. In most cases, the peculiar shattering vibration of a torsional critical speed in the crank shaft is unmistakable. More tangible evidence is often to be found in the difficulty or even impossibility of keeping flywheel and coupling keys tight at the drive end and in the serious heating of couplings and crank shaft fastenings. When the parts are dismantled, they will be found to be abraded due to working under terrific force in close contact without any lubrication. In severe cases, crank shafts have been known to break in a comparatively few days' time. Under criticals of lesser orders, the shaft may endure a much longer time. One of the best indicators of torsional vibration is the timing gears. If these are located at the end opposite the flywheel, they will be excessively noisy at critical speeds and their life may be very short.

Effect of Cylinder Grouping

Torsional vibration is very rarely encountered in engines with four cylinders or less. Six-cylinder engines, which have been speeded beyond the original expectation of the designer, often develop them. The frequency of power impulses in a six-cylinder engine is three times the revolutions per minute. Thus the frequency of the power impulses for a six-cylinder, four-cycle, Diesel engine of single acting type will be 900 per min. Torsional critical speeds in Diesel engines occur in certain relation to each other. For instance, if there is a major critical at 500 r.p.m. there will be another at 250 r.p.m. and perhaps a faint one at 167 r.p.m. That is, they occur in the relation of 1, 1½ and ⅓. They also occur in half orders lying between 1 and ½ and between ½ and ⅓. That is, there should be a critical at 375 r.p.m., also one at 208 r.p.m. Thus the engine may be operated at various speeds above and below normal and if serious vibrations occur in these relations or in more than one of them, the operator may be quite sure that torsional vibration is present.

Critical Speeds May Be Avoided and Overcome

There are two purposes in such studies as this. The first is to avoid such critical speeds as are dangerous. The second is to overcome them when they occur. When the driven unit may be operated at any speed, it is no great trouble to alter the engine speed somewhat and thus avoid criticals. This is particularly practical when the driven unit is a constant speed machine. If the engine is required to operate through a wide speed range, such as 2 to 1 for pumping machinery, any major criticals in the operating range cannot fail to be a nuisance.

When engines are required to drive alternating current generators which are direct connected, particularly when these machines are required to parallel with an outside source of power or with other prime movers in the same plant, there is no choice of speed, for the electrical frequency must be maintained. In this latter case, two practical cures, other than increasing the diameter of the crank shaft, are available for engines operating at or dangerously near a critical speed. If the critical is just below the desired operating speed, it may be advisable to lower the critical speed as the engine may be brought through this critical speed to the operating speed without serious danger. This is usually done by increasing the mass of the shaft with which the torsional spring is weighted and thus lowering its natural frequency.

Proper Counter-weighting Changes Critical Speed

A six-cylinder shaft is a balanced shaft. If counterweights are put on one set of throws they must be put on all or if a very little reduction of frequency is required, such as may be secured by the use of a smaller number of counter-weights, the center cranks which are in line with each other may be counterweighted and two counter-weights may be applied opposite them at the end of the shaft to offset the unbalanced set-up. When it is desired to raise the critical speed out of the operat-

ing range, counter-weighting may be removed, if it has already been placed on the shaft, since it is quite unnecessary or lighter pistons and connecting rods may be substituted, although a considerable change of weight is required here to alter the location of a critical speed to any degree.

Improper Installation May Cause Vibration

Engines that are free from serious torsional vibrations may be incumbered with them due to the set-up demanded by a purchaser. Improper connection with a generator may set them up. To avoid these criticals, the flywheel should be hung as close as possible to the main bearing and the generator should be placed as close to the flywheel as will permit adjustment of the shaft coupling bolts. For present day stationary engine speeds, it is wise to use the largest generator stub shaft that the rotor will take.

A vibrating shaft reaches its maximum amplitude at the free end. Along its length there will be one or more nodes or points of no vibration, the shaft vibrating oppositely on either side of these nodes. At stationary engine speeds, the single node vibration is the only one that needs to be seriously considered. The position of this node approaches closer to the flywheel and generator rotor as these masses are increased. The natural frequency of vibration of the engine shaft itself does not depend on the total length of the shaft but on the length from the free end to the node. Consequently the lighter the flywheel, the shorter the vibrating free end of the crank shaft and the higher its frequency. Thus an engine may be perfectly satisfactory with a flywheel of moderate weight but when fitted with an extremely heavy wheel in the desire to get a very even turning moment, it may develop trouble. It is generally a good rule to use the lightest flywheel that will conform to the requirements of the generator builder.

All of these matters are subject to mathematical analysis but good reasoning will serve in many cases. Many of the foregoing statements are subject to greater refinement when strict scientific accuracy is the object but this extreme refinement may be overlooked in a practical article of this nature.

Power Company Must Safe-Guard Electric Wires

Right of Way Gives No Release from Duty to Protect Other Users of Land. By Leslie Childs

AS A GENERAL rule, where a power company acquires an easement of right of way for its high-voltage wires, its easement extends only for the purpose of passage of its wires and confers only a limited right. Care must be exercised with regard for the rights of others in the premises and failure in this respect, that results in injury to third persons, may render the power company liable.

In a California case the defendant constructed a power line to supply certain of its customers in the county of Los Angeles. This line when constructed passed over a vacant lot, the wires, three in number, being No. 6 bare copper, with no insulation, and about 30 ft. from the ground.

Later, a corrugated iron building was erected on the lot by permission of the owner, so that the defendant's wires passed directly over the peak of the roof 1½ to 5 ft. from the front end with a clearance of about 3 ft. The defendant had notice of the erection of this building and that the close proximity of its wires to the roof thereof created a dangerous condition.

Subsequently, the owner of the building contracted with a sign company to have a sign painted thereon and the plaintiff, who was an employe of the sign company, came to the building for that purpose. He noticed the wires but, as they were small and not insulated, he concluded that they were telephone wires and took no measures to protect himself from contact therewith.

While engaged in placing a stage across the front of the building, he came in contact with the wires and was severely injured, for which injury he brought action against the defendant for damages.

The defendant set up that it had a right of way easement over the lot upon which the building was erected and that the plaintiff was a trespasser or mere licensee at the time of his injury. Hence, the defendant owed the plaintiff no duty of care and, since the evidence did not show active negligence, there was no liability for injury of the plaintiff.

Trial of the cause in the lower court, however, resulted in a judgment against the defendant for $3000. From this the defendant appealed and the higher court, in reviewing the record and in passing upon the duty of the defendant to protect its wires, under its asserted right of easement, in part, said:

Defendant Had No Exclusive Right

Defendant company, in spite of the asserted easement, could not abridge the right of the owner to use of the land for any purpose, provided that such use did not conflict or defeat the rights of the company in the use of its lines. The interest of the company was not exclusive.

It was the duty of the defendant so to erect its lines as to permit the reasonable use of the surface of the soil. In failing to do that, it became itself a trespasser on the rights of the owner and those under him.

As to the further claim that, in coming in contact with the wires, the plaintiff had been guilty of such contributory negligence as should prevent his recovery of damages, the court reasoned as follows:

While one who is aware of a known danger, which should have put him on his guard, cannot deny contributory negligence by showing that he momentarily forgot it, this rule must have a reasonable construction. To forget is not negligence, unless it shows the want of ordinary care.

In this case, since the plaintiff thought, by reason of their small diameter and lack of insulation, that the wires were telephone wires and evidence showed existing danger, there is no merit in this claim.

The court affirmed the judgment of the trial court in favor of the plaintiff and that the defendant was liable for the injury caused by its failure to protect its wires properly, after it had knowledge of the dangerous condition that existed.

This decision constitutes a judicial ruling on the duty of a power company in respect to right of way easement for the passage of its wires.

Industrial Controllers *make possible* Good Motorization

Part II* Discussion of selection of controllers and types available for use with industrial motors

By W. C. YATES†

IN SELECTING the controller best suited for the purpose in mind, its convenience to the operator should not be overlooked. Particularly with machinery which requires constant attention, it is important that the operator find the control within easy reach and manipulate it with little care and effort.

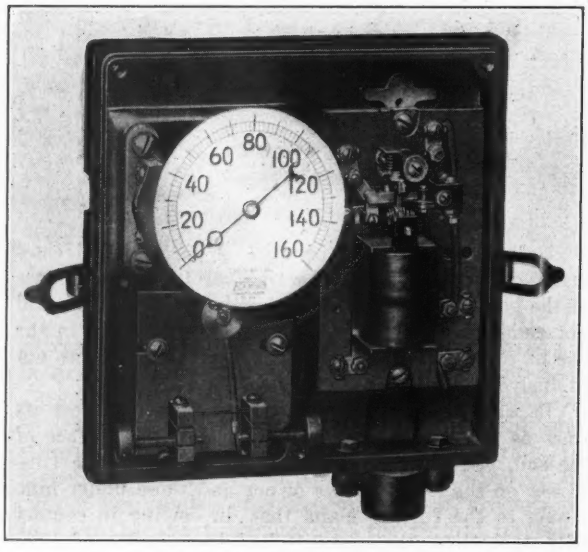


FIG. 1. PRESSURE GOVERNOR WITH RELAY (COVER REMOVED)

Push button or master switch operation of magnetic controllers insures a minimum distraction and responsibility of the operator and a maximum production economy. A control equipment composed of several segregated parts often permits the manually-manipulated parts to be most conveniently located for operation. Frequency of manipulation and the force required to move the controller arm will determine whether a manually operated device will answer the purpose or not. Direction of movement of the controller handle should be considered, particularly on cranes, elevators and hoists. Control from more than one station, as for large printing presses and conveyors, should be considered.

Having determined what the controller has to do and what characteristics and features it must possess, let us turn to the various types available.

One way of broadly subdividing industrial controllers is by the construction of the switching devices. The present day types fall chiefly into three classes: face plate, including dial and knife or snap switch types; drum types, including cam-operated finger types; magnetic types.

The first class covers chiefly general purpose starting devices and certain lines of dial controllers on which the duty is not particularly severe. They are available with adequate protective features and safety enclosures but they are limited to fairly light duty.

Drum controllers in the industrial field are particularly well adapted to manual operation for heavy service, such as cranes, hoists and machine tools. Before the coming of magnetic control, drum controllers were used quite generally and successfully for severe service on large size motors to which it is now quite common to apply magnetic control.

The nature of the service tells whether our controller shall be a manual, a semi-automatic or a full-automatic type. By manual type, we mean one requiring hand operation; by semi-automatic, one that requires at least the initial operation to be personally directed by pressing a button or by some other means, and by full-automatic, a combination such as a pressure governor and magnetic starter that, without attention, will start and stop, to maintain within limits the pressure in a water supply system. A magnetic controller, therefore, may be manually operated by means of a master switch that serves to energize magnetic contactors.

We may be interested in the accelerating method employed in a magnetic starter where the acceleration is automatic. We may find that time element is best suited to our purpose; or perhaps a current limit scheme, one responding to the increasing voltage on the motor armature or the decreasing drop across the starting resistance, is preferable. The availability of dependable timing devices has made time acceleration the method most generally employed.

When it comes to the kind of current reduction in starting motors larger than those that can be thrown directly on the line, we will take it for granted that a resistor of some sort is the thing to use in connection with direct-current motors and with single phase and slip ring multi-phase motors. The squirrel cage induc-

*This is the concluding installment of this article, Part I of which appeared in the August 1, 1929 issue.

†Industrial Dept., General Electric Co.

tion motor, however, may, if the power rules permit, be thrown directly on the line in large sizes; where some method of current reduction is required, we may find reason to consider the relative advantages of a resistance starter as compared with an auto-transformer starter. The latter, commonly called a compensator, has the advantage of putting into the motor more current than it takes from the line and, so far, has proved to be the popular device for starting squirrel cage motors where the starting current is limited.

Open and Enclosed Controllers

Controllers of both open and enclosed types are available; the former, however, are rapidly going out of use in favor of the latter. The manual types have external operating handles and the cases of both the manual and remote control types can be locked shut for safety reasons.

Some controllers will be found to be oil immersed, a feature of particular advantage for three reasons: to afford good insulation between closely assembled switching parts of opposite polarity; to safeguard the switching mechanism against corrosion; to prevent arcing of the switch parts from reaching the outside atmosphere where explosive gases may be present. Oil immersion, contrary to the general impression, is not of any advantage as regards the life of the submerged making and breaking contacts. The same contacts in air with an adequate magnetic blowout, it is claimed, will last 10 times as long as they will when under oil and with the same breaking distance. Controllers subject to frequent service should not have oil immersed switches as the oil will rapidly carbonize and may become a menace.

As accessories to controllers, especially the magnetic types, we shall find available push button stations, master controllers, float switches, pressure and vacuum governors, thermostats, limit switches, and so on that permit us to effect practically any combination desired for the control of the motor.

Much of the increased usefulness of the electric drive in its application to machinery performing more or less complicated evolutions has been made possible by the remarkable developments in the art of magnetic control. Improvements in magnetic contactors, prolonging the life of the contacts and the wear of the device as a whole, have permitted frequent duty cycles of starting, stopping and reversing. Thus we now see motors direct connected to reversing planers, slotters and similar machines and put through their paces, as demanded by such service, easily and safely by an automatic magnetic control that functions incessantly with little attention.

Magnetic control provides for remote operation from push button stations or other forms of master switches, from one or any number of points. The value of this arrangement in connection with the operation of machinery such as printing presses, conveyors and automatic elevators, is obvious. It is possible not only to control the machine from any point but also to lock it against operation from any other point. Such locking safeguards anyone at work on machinery against unexpected restarting.

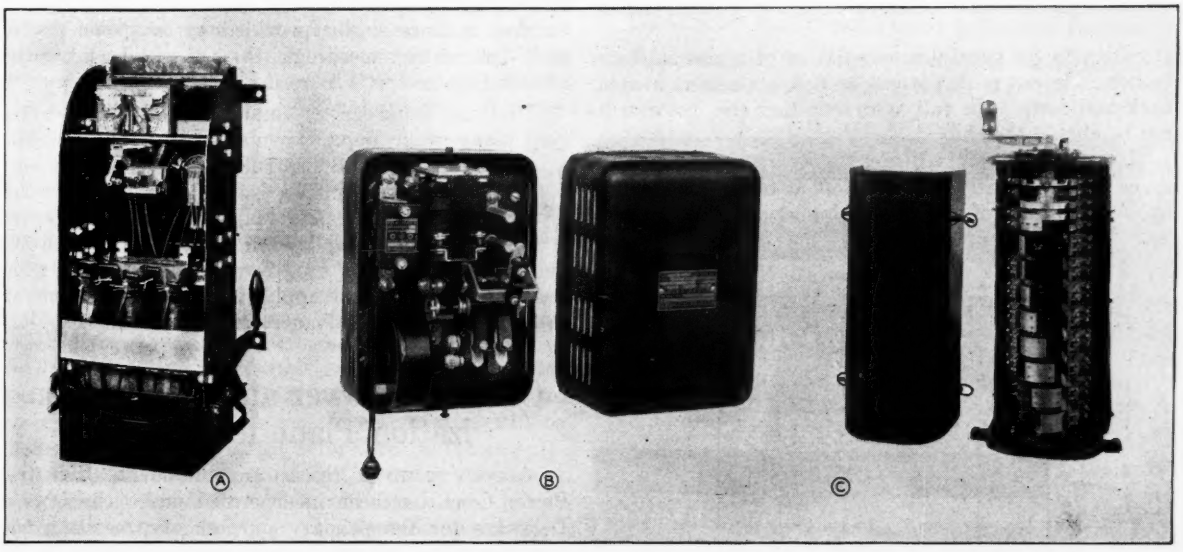


FIG. 2. THREE TYPES OF CONTROLLERS IN COMMON USE
A. Compensator with thermal relay. B. Definite time automatic starter for d.c. motor. C. Typical driven controller.

Magnetic control is employed where automatic operation is required, as in the case of motors driving pumps, which through the medium of a float switch or pressure governor are automatically started and stopped as the water level or pressure rises and falls. Automatic control of temperature can likewise be accomplished by utilizing a thermostat as the pilot control device. The advantages of magnetic control as compared to manual control can be summed up briefly under the following heads:

For ease and convenience of operation, it is obvious that an operator can more easily manipulate push button stations or a small master switch than he can the lever of a large manual controller. Furthermore, it is possible to place the small master device more convenient to the operator's position than is often the case with a large manual controller.

What Magnetic Controllers Can Do

Magnetic control provides for automatic acceleration either by time element, current limit or some other method and the motor is thereby safeguarded against current surges that will result from careless manipulation of a manual control. Besides, the operator is not distracted from the work of his machine by paying

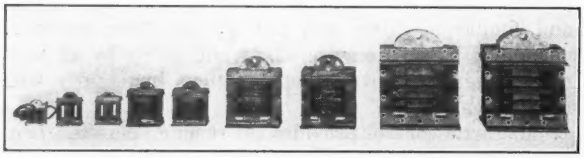


FIG. 3. VARIOUS SIZE SOLENOIDS USED IN CONTROLLERS

attention to the careful manipulation of a manual controller. He can push buttons or throw a master switch back and forth with full assurance that the motor will not be abused thereby.

It is possible to install the magnetic controller where space is conveniently available, off at one side or slung up overhead out of the way. Magnetic control can be

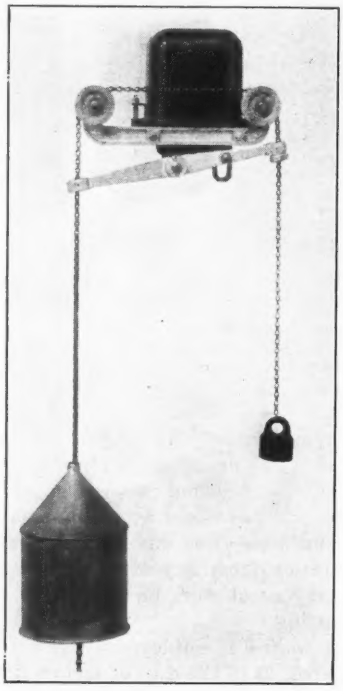


FIG. 4. CHAIN OPERATED FLOAT SWITCH WITH COVER ATTACHED

more easily installed in a direct line from the power supply to the motor, merely running pilot wires to the operator's position. This often makes possible considerable economy in wires and cables.

The automatic acceleration of the motor and the ease of bringing it quickly and safely to rest are also of advantage in safeguarding the driven machinery and the material that may be in it from undue strain or breaking.

Under conditions of frequent and heavy duty, magnetic control has much longer life than manual control even with equally sized contact making parts and equally efficient magnetic blowouts. Magnetic switches close and open with a quick action which is not possible with manually operated contacting devices. Magnetic controllers will also be found more accessible for inspection and repair. From every standpoint, therefore, they are easier to maintain in good operating condition.

From the standpoint of safety to operators and other persons, the magnetic controller is superior, because it can be located out of the way and is less likely to be tampered with. Furthermore, it lends itself to quick stopping by emergency switches and, because of the fact that it will more easily and accurately accelerate the motor and machinery, is an element of safety. Under-voltage protection, a safeguard to the operator against unexpected restarting when power returns after failure, is more surely provided by magnetic control and, generally speaking, the overload protection afforded the motor is more dependable.

Dial and drum starters and controllers have undergone many recent improvements particularly as regards safety precautions and are fully suitable for the purposes intended, particularly where the motors are small or the service infrequent. Magnetic control, however, is the rapidly growing branch of the art in both size and variety. It has outgrown the ability of many people interested in the application of industrial motors to keep up with the advances made.

Combined Power and Coal-Carbonization Plant for Chicago

According to a recent announcement, Industrial Power Corp. has been incorporated under the laws of Delaware for the primary purpose of processing coal and furnishing electric power, gas and steam to the manufacturing and stockyards district of Chicago and the surrounding industrial area. According to this announcement, a central power plant of about 100,000 kw. capacity will be erected.

Fuel for this station is to be secured from a low-temperature carbonization plant which will be designed to produce valuable by-products in the form of tar, oils and other substances, in addition to a solid fuel that can be used for industrial or domestic purposes. It is reported that the coal processing plant will be designed for an ultimate capacity of 45,000,000 cu. ft. of gas daily, which will be used in the industrial area about the property.

Properties acquired by the industrial corporation include frontage on the Chicago River, access to railways which may eventually be electrified and the Produce Terminal Corp., which has been in operation for several years.

According to the announcement, large savings in fuel, labor and investment costs will be affected by the centralization of the power and steam requirements of a large group of industries and much valuable property will be released for manufacturing purposes.

Stevens & Wood, consulting enginers, are completing the survey of the properties to be served and are preparing plans for the new development. It is stated that work on the new plants will be started soon, as the schedule provides for delivery of service early in 1930.

Electricity---What It Is and How It Acts*

PART XXVII. ENERGY TRANSFORMATIONS WITHIN THE ATOM. ORIGIN OF SPECTRAL LINES. THE PRINCIPLE AND PRODUCTION OF X-RAYS. BY A. W. KRAMER.

FROM A CONSIDERATION of the phenomena discussed in the previous article, it is evident that the amount of energy required to displace an electron in an atom from an inner orbit to an outer orbit is a fixed quantity. That is, before an impinging electron can knock an atomic electron from an inner orbit into an outer orbit, it must acquire a certain velocity, hence a certain amount of energy. If the impinging electron collides with the atom at a velocity less than that required to excite the atom, it will merely be deflected, i.e., none of its kinetic energy will be absorbed by the atom in moving one of the orbital electrons to an outer position.

It is also evident that more energy is required to displace electrons in the atom from orbits close to the nucleus than is required to displace electrons in orbits more removed from the nucleus. Naturally, the electrons in the inner orbits are held more firmly than those in the outer orbits.

This being so, it follows that as the excitation potential is progressively increased, there will be a progressive displacement of the electrons, starting with those in the outer orbits. Of course, as the excitation potential is increased, the ionization potential will be reached and at this point (or before, due to the cumulative effect) the outer electrons will be removed entirely, thus ionizing the atom. This will occur long before electrons in some of the inner orbits are displaced.

THE ORIGIN OF SPECTRAL LINES

It is this action which is responsible for the spectral lines in the spectrum of gases. It is well known that when incandescent vapors and gases are viewed through the spectroscope, the spectrum observed consists of bright lines on a dark background. These lines, for different elements, have different positions on the dark background, no two elements giving spectral lines in exactly the same position in the field. Thus an element may be detected merely by observing its spectral lines and comparing them with the spectral lines of known substances.

These spectral lines are produced by the "falling in" of electrons which have been displaced from their normal orbits, as described in the previous article. In Fig. 1 are shown a series of spectra obtained by Foote and Mohler, which show this clearly. Foote and Mohler fired electrons into potassium vapor and examined the nature of the light emitted by means of the spectroscope. When the exciting electron fell through 3.5 v., they obtained the single line spectrum shown at the top which lay in the ultra red portion of the spectrum. Potassium vapor has an ionization potential of only about 4 v., therefore, with an excitation potential of 7 v. these observers obtained the arc spectra shown. With this voltage, the impinging electron removed an electron right out of the potassium atom and at a later stage more than one electron was removed, leaving the atom with a surplus of two positive charges. Under these conditions, with a 25-v. excitation potential the enhanced spectrum was obtained. Proceeding along this line, it is possible to follow out very clearly the conditions in which various series types of spectral lines are generated.

PORTION OF ELECTRONS FIXED BY ENERGY LEVELS

It seems from these experiments and those that have been described in previous articles, that the orbits in the atoms are fixed definitely by the amounts of energy necessary to move electrons out of the orbits.

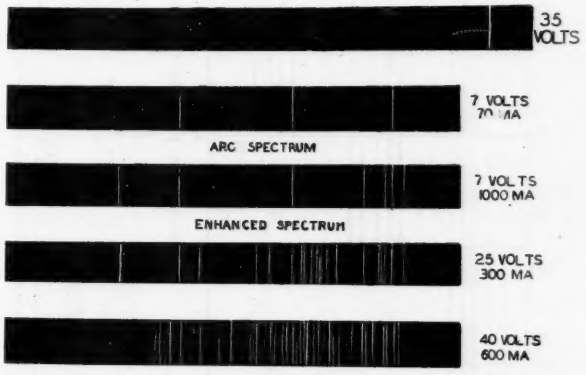


FIG. 1. A GROUP OF SPECTRA OBTAINED BY FOOTE AND MOHLER FROM POTASSIUM VAPOR IONIZED BY ELECTRONIC IMPACT

Consider the simplest case, that of the hydrogen atom, which has only a single electron. The different energy levels, at which this electron might be temporarily stable are shown in Fig. 2. In its innermost and permanent position, the electron revolves in a circle, and has an energy level indicated by the lowest line in Fig. 2. If this atom is ionized, the electron is entirely removed, but if the excitation voltage is less than the ionizing potential, it may be jumped up to any of the possible orbits, defined by the Bohr theory and which are represented by the different levels or orbits shown in Fig. 2. From this figure, it is seen that, to remove an electron completely from the innermost orbit to a point outside the atom requires an expenditure of energy equal to 215.6×10^{-13} ergs.[1]

By means of different excitation potentials, the electron of the hydrogen atom may be displaced to any of the different energy levels or orbits shown in Fig 2. When this electron returns to the second energy level, the ordinary hydrogen spectrum is produced. If it falls to the first level, the spectral lines in the ultra violet part of the spectrum are produced.

An electron displaced into an orbit of lower energy

*All rights reserved.

[1]An erg is the unit of work and is the work done by a force of 1 dyne moving through 1 centimeter. See Part XVIII, Feb. 15, 1929 issue, p. 250.

level does not always fall back directly into its original orbit. The atom cannot revert from all excited states into the normal condition; nor can it be transposed into these states by absorption. In reverting to its normal state, an electron often has to pass through one or more intermediate states. The action is illustrated in Fig. 4. In this diagram are depicted the outer energy levels of a heavy atom. The energy level at infinite withdrawal is designated by O. An electron whose normal energy level is D in this case is excited up to energy level A. In reverting to its original state, however,

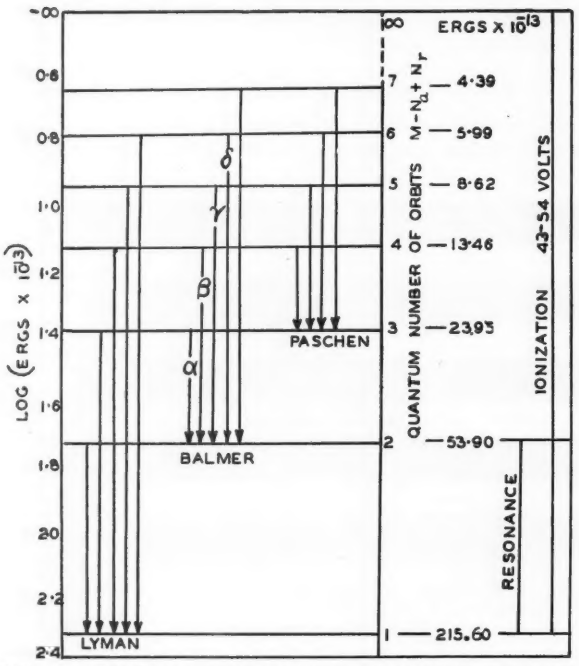


FIG. 2. DIAGRAM SHOWING THE POSSIBLE ENERGY LEVELS FOR AN ELECTRON IN THE HYDROGEN ATOM

this electron cannot fall back directly to energy level D. Instead it must fall successively into energy levels B and C and then finally into D.

In the same manner, the spectra for all elements are produced although, for ordinary elements with atoms having large numbers of electrons, the process is more complicated. With each return of an electron to an orbit of higher energy level, a pulse of radiation is sent out which is capable of producing its particular spectral line. No single atom at any one moment can emit all the lines of its spectrum but when a great many atoms are radiating, as in the case of a gas-filled tube rendered luminous by an electric discharge, the complete spectrum is produced as the sum of the individual contributions.

The line spectra we have been considering are produced only by elementary substances when in the form of a gas or vapor. In this state, the atoms have plenty of room to vibrate as individual units.

When a substance is in the solid or liquid state, however, the atoms are packed closely and can no longer vibrate as individuals. In this case, the atomic systems vibrate as parts of the whole number of systems constituting the solid or liquid under consideration. Each atom is limited in the expression of its tendencies (the tendency to produce line spectrum) by the interrelations with its neighbors. Energy imparted to an atom under these conditions results not in a displacement of electrons in that atom but in a chaotic motion on the part of all the other atoms. Instead of a clear individual expression, which is characteristic of the atomic type, there arises, as John Mills puts it,[2] a roar of notes expressive only of conflict and chaos. As a consequence, instead of the line spectrum emitted by a gas, a solid or liquid produces a continuous spectrum, that is, one which shows only a band of color.

Our discussion thus far has been only on the effect of collision between normal atoms and what may be termed slow moving electrons, that is electrons accelerated by potentials from 0 to say 100 v. Suppose instead of 10, 20 or 50 v., voltages of 100,000 or 200,000 are used. With these excitation voltages, the velocity of the electron will be increased enormously, so that when colliding with an atom it can impart much more energy to the atom than when moving at the slow speeds previously considered. Under such potentials, energy levels can be mapped out right into the center of the atom.

Production of X-rays

In this case, also, radiation is produced but this radiation is due not to electrons in the outer orbits of the

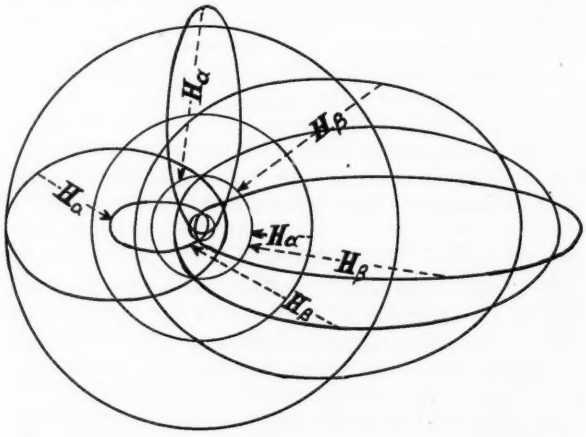


FIG. 3. A FEW OF THE INNER ORBITS WHICH MAY BE OCCUPIED BY THE ELECTRON OF THE HYDROGEN ATOM

(This might be called an instantaneous photograph of the possible orbits of the atom. Actually these orbits are perturbed so that they are not actually closed or cyclic.)

atom but to those very close to the nucleus. The radiation in this case also is not visible to the eye for the waves are much shorter than those of visible light. These waves are the X-rays, first discovered by Roentgen, and are some 10,000 times shorter than visible light waves.

X-rays are produced in a manner similar to that outlined for the production of light by electronic impact but instead of directing the impinging electrons against gaseous molecules and atoms, they are directed against a solid metal target.

A modern X-ray tube is shown in Fig. 5. This is the Coolidge tube which was developed by Dr. W. D. Coolidge of the General Electric Co. As may be noted it consists of a vacuum tube in which are fitted a

[2]Within the atom.

cathode consisting of a spiral of tungsten wire and an anode consisting of a massive block of tungsten. The cathode is heated by passing through it a current from a battery or other source. The anode is maintained positive with respect to the cathode by a source of extremely high potential. The entire affair, it will be seen, is nothing more nor less than another form of the two electrode vacuum tube described in previous articles.[3] Electrons evaporated from the tungsten filament by thermionic action are drawn across to the anode at high velocity. In order to focus the stream of electrons directly upon the anode the cathode is enclosed in a tube of molybdenum. Thus, the anode is subjected to a terrific bombardment by electrons traveling anywhere from 30,000 to 100,000 m. per sec. depending upon the voltage employed.

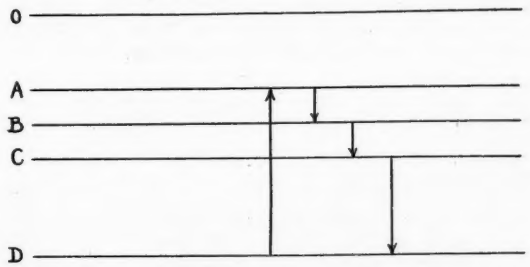


FIG. 4. DIAGRAM SHOWING HOW AN ELECTRON MAY BE COMPELLED TO PASS THROUGH SEVERAL INTERMEDIATE STATES BEFORE REVERTING TO ITS NORMAL CONDITION

(An electron whose normal energy level is D in this case is excited up to level A. In reverting to its original state, this electron cannot fall back to level D directly but must fall successively into levels B and C before finally falling to D.)

Under the force of the collision, the electrons violently displace from their orbits some of the electrons of the atoms upon which they fall. In this respect, the action is similar to that already discussed but in the X-ray tube, because of the high velocities involved, the bombardment affects not only the electrons more or less loosely held in the outer shells of the atoms—those which account for valence and ionization—but affects also the electrons in the inner orbits. These are displaced to new orbits from which they return to their original ones, the return being accompanied by an emission of radiant energy.

Because these inner electrons are closely bound to the nucleus, the restoring forces are large and the frequency of the emitted wave high, in much the same way that the tightening of a violin string increases the pitch of the note. X-rays, because of their very much higher frequency than light waves, are invisible to the eye. They may be detected, however, by chemical or electrical means. If they are permitted to fall upon a screen coated with platino-barium cyanide, they will excite this coating to a brilliant fluorescence. Because of the extremely short wave length, X-rays are capable of passing through matter which is opaque to ordinary visible light and in this property lies their chief value. Naturally, these rays penetrate various substances in different degrees; for instance, flesh more easily than bone. If, therefore, the body to be investigated is placed between the X-ray tube and the platino-barium cyanide screen, a shadow image showing the internal character of the body may be observed on the screen.

[3]Parts XIX and XX, March 1 and March 15, 1929, respectively.

Frequency of X-rays Proportional to Energy of Electrons

As in the case of light waves, the frequencies of the X-rays produced is always proportional to the energy of the electron, and therefore proportional to the potential imposed on the tube. This ratio remains the same no matter what is the intensity of the electron discharge and no matter what the nature of the target. In the X-ray tube, the target or anode is made of tungsten because of the ability of this metal to withstand high temperatures but any other metal would do as well, provided it could be kept from melting. The ratio of electron energy to the frequency of radiation is the number which we introduced in the previous article; it is known as Planck's constant and is denoted by h. Its value is 6.55×10^{-27}.

Although this constant appears in many ways, there is probably no instance where the transformation of energy which it governs is so simply displayed or so easily measured as in the case of X-rays. In certain measurements made by Duane at Harvard University where the potential across the X-ray tube was derived from a great storage battery of 20,000 v., the X-ray spectrometer was set to observe the presence of a certain frequency as soon as it appeared. The potential on the

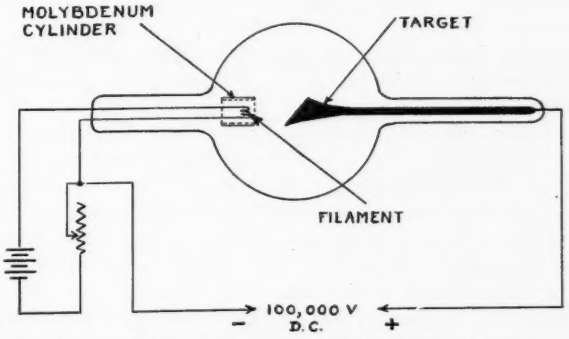


FIG. 5. DIAGRAM OF THE COOLIDGE X-RAY TUBE

(Electrons emitted by the incandescent filament are drawn across to the inclined face of the target or anode under the influence of an extremely high electric potential. They impinge against the atoms of the target with terrific force, thereby exciting the atoms and causing them to emit X-rays.)

tube was then increased by degrees. The rays of given frequency appeared as soon as the energy supplied to the electron was equal to the frequency multiplied by h.

From these experiments and from the previous discussion, it will be evident that the production of X-rays is not an aggregate of individual efforts by separate electrons but that each electron produces its own train of X-rays when it strikes the target. There is no sign of any combined action. The intensity of the electron stream is without influence on the frequencies of the X-rays produced.

In any stream of X-rays, however, a number of different frequencies will be observed, but always there will be a definite upper limit of frequency. The emission of more than one frequency is due to the fact that the total energy of an electron is not always transformed into X-rays during the stimulation of the solid anode. The emission of a given frequency by means

of the energy of the electron can occur only if the "excited" atom is capable of accepting this energy; that is, there is a question here not only of the quantum law in regard to radiation but also to atomic structure.

As stated before, the only difference between X-rays and visible light waves is in the frequency. Both are forms of electromagnetic radiation and both travel at the same speed, i.e., 186,000 mi. per sec. or as it is usually expressed, 3×10^{10} centimeters per sec. To obtain the wave length of either type of radiation or

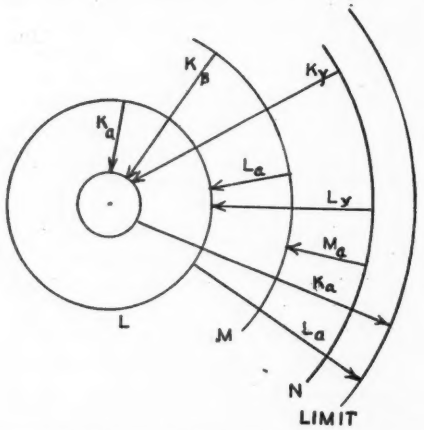


FIG. 6. THE ENERGY LEVELS OF A HEAVY ATOM. THE ELECTRONS MOST DIFFICULT TO REMOVE ARE THOSE OCCUPYING THE K ORBIT

of any form of electromagnetic radiation, it is merely necessary to divide the speed of light by the frequency. Thus $W = V \div f$.

The penetrating power of the X-ray is proportional to the frequency or the wave length. The shorter the wave length, the greater the penetration. The shorter waves of course are produced by electrons whose normal orbits are closest to the nucleus. By means of the X-ray spectrometer, the energy levels of the inner orbits can be mapped out in the same way that they are determined in the case of visible light. In Fig. 6 are shown the energy levels or the orbits for a heavy atom. The electrons most difficult to remove or displace are those occupying the K orbit.

Administration of Premium System

BASES OF AWARDS FOR MAINTAINING PLANT APPEARANCES FOSTERED BY THE PACIFIC GAS & ELECTRIC CO.

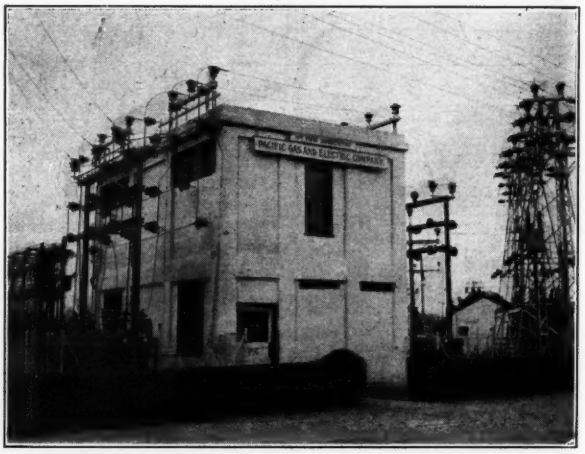
SOME YEARS ago, the Pacific Gas & Electric Co. inaugurated a premium system covering the housekeeping of electric and steam properties. The general control and administration of all matters in connection with the system is vested in a general rating committee selected by the vice-president in charge of electrical construction and operation.

Rating of properties in the divisions are conducted by a committee of three employes in each division appointed by the division managers. Each divisional committee visits the properties and determines and reports the rating of each.

Divisional reports when received are referred to the general rating committee, which, as soon as practicable after all have been received, inspect as many of the properties in each class receiving the highest ratings in each division as in its judgment, may be necessary fairly to determine the awards in accordance with the rating plan. The general committee in submitting its report to the vice-president, lists such other properties as in its judgment and discretion deserve favorable mention.

Awards are made annually for each calendar year. Suitable premiums in recognition of the awards are presented at or near the end of the year, to be retained by the winning properties during the ensuing year.

The general rating committee determines the award of first, second and third prizes in each of three classes of properties, electric substations, steam plants, and hydroelectric plants, in competition with all properties of the company in those respective classes. The property which receives the highest rating of all properties in all classes receives special recognition.



MT. VIEW SUBSTATION IS A CONSISTENT WINNER OF PRIZES FOR APPEARANCES

In addition, the committee awards a premium to that property in each division which receives the highest rating of all properties, regardless of class, in that division.

The rating schedule follows:

	Subdivision of Property	Maximum Merits Obtainable
A	Grounds	150
B	Buildings and Structures	200
C	Employe Attendants	25
D	Records	25
E	Materials, Supplies, Tools, Equipment	150
F	Stationary Electrical Equipment	150
G	Rotating Electric Equipment	100
H	Hydro Prime Mover Equipment	150
I	Hydraulic Structures and Equipment	100
J	Steam Prime Mover Equipment	150
K	Steam Boiler Equipment	100

The rating of each property will be the percentage of the merits earned to the total of the merits obtainable for those items, under the several subdivisions, which are present in the property.

New 165,000-Kw. Unit No. 3 at Philo in Service

ORIGINAL ULTIMATE STATION CAPACITY OF 240,000 KW. COMPLETED BY NEW MACHINE WHICH TAKES THE PLACE OF FOUR 40,000-KW. TURBINES PLANNED FOR ORIGINALLY

PHILO STATION of the Ohio Power Co., a subsidiary of American Gas & Electric Co., has put into operation its third generator unit, rated at 165,000-kw. capacity and supplied with steam by four standard boilers with a capacity of 250,000 lb. an hour each and two reheat boilers with a steaming capacity of 149,000 lb. an hr. each and a reheat capacity of 750,000 lb. an hr. each.

Comparison of the third unit at Philo with the two originally installed in 1924 shows several interesting changes in detail. The original installation of 40,000-kw. units was described in the June 1, 1925 issue of Power Plant Engineering. As noted in that article, the plant established what was at that time a record for economy with a rate of 14,343 B.t.u. per kw-hr. output.

Philo Station operates as a base load station; it is essentially a manufacturing plant delivering its product, electric power, to the outgoing side of its transformers, where its responsibility ceases.

It is interesting to note that the plant was originally designed for six 40,000-kw. units, whereas after the two initial units were put in, the third unit has a capacity equal to the next four that were originally planned and there is space enough for installation of a similar 165,000-kw. unit in the future.

Originally, the plant was built beside an old canal running between two points on a bend of the Muskingum River. A dam at this point provides sufficient head so that circulating water from the river flows by gravity through the condensers for about 10 mos. of the year; circulating pumps were installed for use during the remaining 2 mos. of low water. The lower end of the canal formed a convenient space for storage of coal under water. The entire condenser water circulating system and coal storage system were designed for the ultimate plant, so that no additions had to be made to these in installing the third unit.

The new 165,000-kw. unit is a three-cylinder compound machine with one 17-stage, high-pressure and two 12-stage low-pressure cylinders. All three rotors operate at 1800 r.p.m. Each low-pressure cylinder drives a 56,000-kw., 11,000-v. generator, a 3000-kw. auxiliary generator and a direct-connected exciter. The high-pressure cylinder drives a 53,000-kw., 11,000-v. generator and its exciter.

Steam at a throttle pressure of 615 lb. abs. and 725 deg. total temperature flows to the high pressure cylinder, leaves this cylinder after expansion to 138 lb. abs., flows back to the reheat boilers in the boiler room, where its temperature is raised again to 725 deg., and passes then to the two low-pressure cylinders.

These exhaust at 1 in. of mercury to two horizontal condensers in the pit below them. Condensers are of the two-compartment, opposed-flow type, each having a surface of 50,000 sq. ft. Circulating water flows from the canal by gravity through a new intake tunnel. For low water operation during two months of the year, each condenser has two 50,000-g.p.m., 14-ft. head, motor driven circulating pumps.

Steam for feedwater heating and evaporating is extracted from the turbine cylinders at the following pressures and stages: high pressure cylinder exhausts at 138 lb. abs.; low pressure cylinders 3, 6 and 9 stages at 60, 22.7 and 6.15 lb. abs. The existing water treatment plant was enlarged to provide a capacity of 36,000 g.p.m. and two deaerators and two direct contact heaters, of 750,000 lb. an hour capacity each were installed besides the extraction heaters noted on the list of equipment. The evaporator for makeup water is a two-effect unit of 25,000 lb. an hour capacity.

Boilers designed for pressure of 747 lb. abs., 750 deg. total temperature, are set as shown in Fig. 2, the

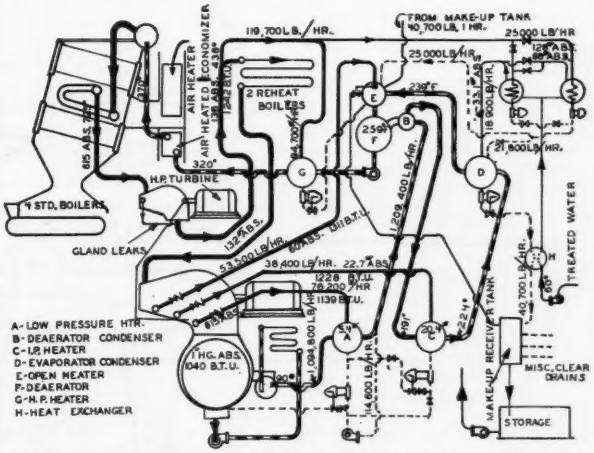


FIG. 1. THE NEW UNIT HAS ONE HIGH-PRESSURE AND TWO LOW-PRESSURE ELEMENTS

boilers of the two 40,000-kw. units being shown at the left and the new boilers at the right. The furnaces for the new boilers are entirely water-cooled, about one-fourth of the surface being of armored tubes and the remainder of refractory covered tubes. Provision is made in the ignition arch for admission of over-fire air. Compressed air at 100 lb. is used for soot blowing.

Combustion air is heated by plate type air preheaters to about 530 deg. and is then tempered to 375 deg. for the stokers by passing it through air-water economizers, as at Stanton.

Forced and induced draft fans are of the new variable inlet vane control type with automatic control. Each forced draft fan is driven by a 600/900/1200-r.p.m. squirrel cage motor. Each induced draft fan is driven by two motors, one a 720-r.p.m., single-speed motor for normal operation, the other a two-speed, 450/900-r.p.m. motor for use at high or low ratings.

Like the original section, this addition to Philo was designed by Sargent & Lundy, Inc., of Chicago, coöperating with the engineers of the American Gas & Electric Co.

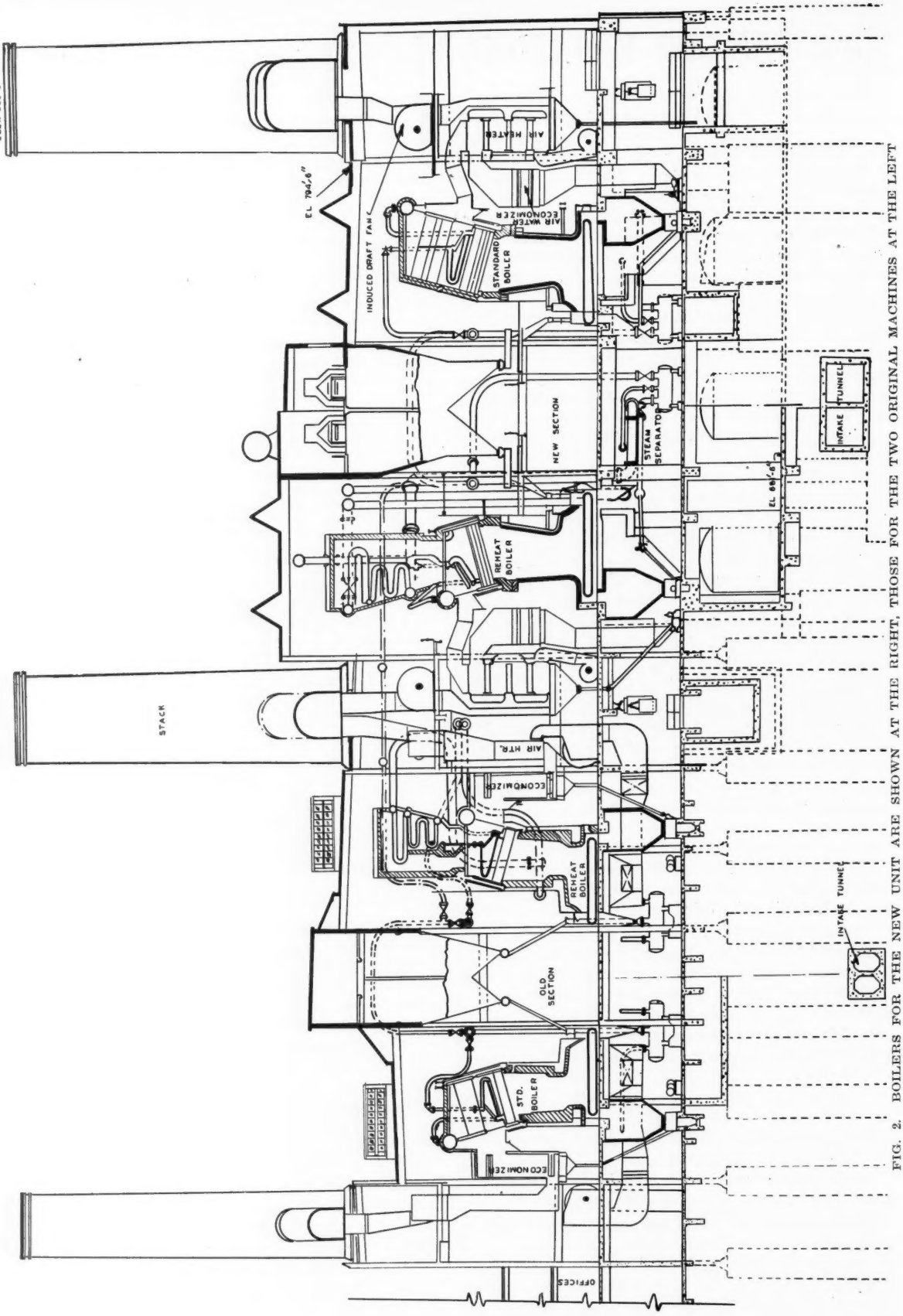


FIG. 2. BOILERS FOR THE NEW UNIT ARE SHOWN AT THE RIGHT, THOSE FOR THE TWO ORIGINAL MACHINES AT THE LEFT

Principal Equipment, Philo Power Station, Unit No. 3

Owner ..... Ohio Power Co.
Service ..... Power and Light
Location ..... Philo, Ohio
Present capacity of station .... 245,000 kw
Water source ..... Muskingum River
Consulting engineers. Sargent & Lundy, Inc.
Cu. ft. per kw. volume, present building, total 46.76

STANDARD BOILERS .. Babcock & Wilcox Co.
Number 4
Type ..... Cross drum
Surface ..... 21,551 sq. ft.
Design pressure ..... 747 lb. abs.
Steam temperature total ..... 750 deg. F.
Steaming capacity ..... 250,000 lb.-hr.

REHEAT BOILERS .... Babcock & Wilcox Co.
Number 2
Steaming surface ..... 4,734 sq. ft.
Steaming capacity ..... 149,000 lb.-hr.
Reheat surface ..... 24,723 sq. ft.
Reheat capacity ..... 750,000 lb.-hr.
Steam pressure at reheat ..... 338 lb. abs.
Temp. entering reheater ..... 438 deg. F.
Temp. leaving reheater ..... 710 deg. F.
SOOT BLOWERS .... Diamond Pr. Spec. Co.
WATER-COOLED FURNACES ..... Foster-Wheeler Corp..
Total surfaces, each ..... 1,597 sq. ft.
One ignition arch ..... Detrick type

ECONOMIZERS ..... Babcock & Wilcox Co.
Type ..... Air-water
Surface ..... 15,772 sq. ft.
Air temperature—In ..... 527 deg F.
Air temperature—Out ..... 367 deg. F.
Water temperature—In ..... 320 deg. F.
Water temperature—Out ..... 367 deg. F.

AIR HEATERS ..... Foster-Wheeler Corp.
Number 6
Type ..... Plate
Number sections 16
Heating surface ..... 51,000 sq. ft.
Gas temperature—In ..... 745 deg. F.
Gas temperature—Out ..... 395 deg. F.
Air temperature—In ..... 100 deg. F.
Air temperature—Out ..... 527 deg. F.

STOKERS ..... Babcock & Wilcox Co.
Type ..... Forced draft, chain crate
Effective surface ..... 528 sq. ft.
Drive ..... D.c. var. speed motor
Normal air temperature ..... 375 deg. F.

FORCED DRAFT FANS .. B. F. Sturtevant Co.
Number 12
Type ..... Adjustable inlet vane
Capacity @ 1200 r.p.m. ..... 50,000 c.f.m.
Pressure @ 1200 r.p.m. ..... 15.8 c.f.m.
Air temperature ..... 100 deg. F.
Speeds ..... 600-900-1200 r.p.m.
Drive ..... Three speed-sq. cage motor

INDUCED DRAFT FANS. B. F. Sturtevant Co.
Number 6
Type ..... Adjustable inlet vanes
Capacity @ 900 r.p.m. ..... 175,000 c.f.m.
Temperature of gas ..... 395 deg. F.
Suction ..... 10.2 in.
Speeds ..... 450-720-900 r.p.m.
Drive—450-900 two-speed sq. cg. motor and 1—720 single-speed sq. cage motor.
Vane control ..... Cutler-Hammer Co.

TURBO-GENERATOR— .. General Electric Co.
Number of units ..... One 3-cyl. compound
Size unit ..... 165,000 kw., 85 per cent p.f.
High-pressure element ..... 53,000 kw.
Low-pressure elements ... 56,000 kw. each
No. aux. generators .... 1 on each l.p. cyl.
Each aux. generator ..... 3000 kw.
Steam press. at throttle ..... 615 lb. abs.
Steam temperature ..... 725 deg. F.
Final reheat temperature at turbine .... 725 deg. F.
Exhaust pressure ..... 1 in. hg. abs.
Generator voltage 11,000
Speed, all cylinders ..... 1800 r.p.m.

CONDENSING EQUIPMENT ..... Foster-Wheeler Corp.

CONDENSERS
Number 2
Type ..... 2-compartment, opposed flow
Surface, each ..... 50,000 sq. ft.
Tubes .. One end expanded, other packed
Reversing flow ..... Special baffles
Phillips expansion joints.

AIR COOLERS
Type ..... Finned tube
Number 2
Surface, each ..... 5000 sq. ft.
Circulating water required .. 3000 g.p.m.

STEAM JET AIR PUMPS
Type 3-element, 3-stage
Number 2
Air removal ..... 26.3 c.f.m.
Per stage per element at ..... 1 in. abs.

HOT WELL PUMPS
Number ..... 2 per condenser
Size and type 8-in., 3-stage
Capacity ..... 1400 g.p.m.
Head ..... 240 ft.
Speed and drive ..... 1170 r.p.m., a.c., var. speed motor

CIRCULATING PUMPS
Number ..... 2 per condenser
Size ..... 48 in.
Capacity, each ..... 50,000 g.p.m.
Head ..... 14 ft.
Speed ..... 230 r.p.m.
Drive ..... Sq. cage motor

FEEDWATER HEATING EQUIPMENT

DEAERATORS ..... Elliott Co.
Type ..... External vapor condenser
Maximum working pressure .... 65 lb. gal.
Number 2
Capacity ..... 750,000 lb.-hr.
Vapor condensers ..... 2 pass
Surface ..... 1290 sq. ft
Vacuum pumps ..... Nash Hytor
Number ..... 2 per unit

DIRECT CONTACT HEATERS. Hoppes Mfg. Co.
Number 2
Capacity ..... 750,000 lb.-hr.
Temperature rise ..... 45 deg. F.
Heating surface ..... 875 sq. ft.
Hot-water storage ..... 6200 gal.
Maximum working pressure .... 65 lb. gal.

L. P. EXTRACTION HEATERS ..... Foster-Wheeler Corp.
Number 2
Type ..... 4-pass, vertical, U tube
Surface ..... 3040 sq. ft.
Capacity .. 600,000 lb.-hr., 90 to 160 deg. F.

L. P. EXTRACTION HEATERS ..... Foster-Wheeler Corp.
Number 2
Type ..... 4-pass, vertical, U tube
Surface ..... 3040 sq. ft.
Capacity | 675,000 lb.-hr., 191 to 224 deg. F.

H. P. EXTRACTION HEATERS ..... Foster-Wheeler Corp.
Number 2
Type ..... 4-pass, vertical, U tube
Surface ..... 2460 sq. ft.
Capacity. 750,000 lb.-hr., 259 to 320 deg. F.

HEATER DRAIN PUMPS .. Yeomans Bros. Co.
Number 3
Capacity ..... 150 g.p.m.
Total head ..... 300 ft.
Drive ..... Sq. cage motor

EVAPORATOR ..... Foster-Wheeler Corp.
Number 2
Type ..... High pressure, double effect
Heating surface, per effect ..... 600 sq. ft.
Vapor condenser ..... 850 sq. ft.
Heat exchanger ..... 100 sq. ft.
Capacity, distilled water ..... 25,000 lb.-hr.

BOILER FEED PUMPS ..... (Cameron), Ingersoll-Rand Co.
Number ..... 2—turbine, 4—motor driven
Type ..... 6-stage, centrifugal
Capacity, each ..... 750 g.p.m.
Total head ..... 850 lb.-sq. in.
Speed ..... 1750 r.p.m.
Drives—700-hp., 2200-v. motors and 600-hp. steam turbines—Westinghouse.

MISCELLANEOUS PUMPS

BILGE PUMPS ..... Yeomans Bros. Co.
For condenser pit 2
Capacity, each ..... 750 g.p.m.
For boiler room sub-basement 2
Capacity ..... 450-500 g.p.m.

DEEP WELL PUMPS ... American Well Wks.
Number 3
Capacity ..... 750 g.p.m.

MAKE-UP PUMPS ..... Scranton Pump Co.
For ..... Units (1 and 2)
Number 2
Type ..... 2-stage, centrifugal
Capacity ..... 100 g.p.m.

PRIMARY MAKE-UP PUMPS ..... Scranton Pump Co.
Number 4
Type ..... 3-stage, centrifugal
Capacity ..... 100 g.p.m.
Head ..... 250-265 ft.

TREATED WATER PUMPS ..... Scranton Pump Co.
Number 2
Type ..... 2-stage, centrifugal
Capacity ..... 100 g.p.m.

EVAPORATOR SUPPLY PUMPS ..... Scranton Pump Co.
Number 2
Type ..... 2-stage, centrifugal
Capacity ..... 100 g.p.m.

DISTILLED WATER PUMPS ..... Scranton Pump Co.
Number 2
Type ..... 2-stage, centrifugal
Capacity ..... 200 g.p.m.

COAL AND ASH HANDLING EQUIPMENT

AUTOMATIC COAL SCALES ..... Richardson Scale Co.
Number 12
Capacity, each ..... 12 ton-hr.
Type ... Automatic apron feed-motor drive

COAL FEEDERS ..... Henry Pratt Co.
Coal valves 12
Swinging spouts 24
Spout swingers, automatic 6

CINDER CRUSHER ..... Westinghouse Electric & Mfg. Co.
Two grinders per boiler.

ASH SLUICING EQUIPMENT ..... Allen-Sherman-Hoff Co.
Type ..... Hydrojet

CRANES AND HOISTS

ASH TRANSPORTATION ..... Milwaukee El. Crane Co.
Number 1
Type ..... 3-motor, Monorail bucket hoist
Capacity ..... 4800 lb.

CONDENSER WELL CRANE ..... Milwaukee El. Crane Co.
Type ..... 3-motor, bridge
Capacity ..... 15 t.

SCREEN HANDLING CRANE ... Whiting Corp.
Type ..... Monorail, hand-operated motor hoist
Capacity ..... 25 t.

VARIOUS HOISTS ..... Detroit Hoist & Machine Co.
One 5-t. el. hoist ..... Boiler room
Two 3-t. ch. hoist ..... Evaporator service
One 2-t. ch. hoist ..... Crib house
Two 2-t. pl. trolley ..... Crib house
Two 7-t. pl. trolley. Induced draft fan flrs.

TRAVELING SCREENS ..... Chain Belt Co.
Number 7
Length, center to cen ..... 36 ft. 10½ in.
Speed ..... 6-9 f.p.m.

AIR COMPRESSOR ... Sullivan Machinery Co.
Number 1
Type ..... 2-stage, angle compound
Pressure ..... 125 lb-sq. in.
Speed ..... 257 r.p.m.
Capacity, free air ..... 1131 c.f.m.
Drive ..... Synchronous motor

MISCELLANEOUS TANKS

AIR RECEIVERS ..... Biggs Boiler Works
BLOW-OFF TANK ..... Biggs Boiler Works
MAKE-UP SURGE TANKS. Biggs Boiler Wks.
DISTILLED WATER TANKS ..... Pittsburgh-Des Moines Steel Co.
STEAM SEPARATOR ..... M. W. Kellogg Co.
Number 2
Size ..... 40 in. dia., 12 ft. 8 in. length
Design working pressure .. 750 lb-sq. in. G.
Design working temperature ... 800 deg. F.

PIPING
H. P. and reheat piping ..... Pitts. Piping & Equip. Co.
Circulating water piping ..... Pitts. Piping & Equip. Co.
Pipe covering and insulation ..... Ehret Magnesia Co.
Valves ..... Automatic Non-Return Schutte & Koerting Co.
Blow-off ..... Yarnall-Waring & Edward Valve & Mfg. Co.
H. P. steam and gate valves .. Crane Co.
Safety valves ..... Consolidated-Ashcroft Hancock Co.
Feedwater regulators .... Swartwout Co.
Valve motors and control ..... Cutler-Hammer Co.

ELEVATORS ..... Otis Elevator Co.
WATER TREATING PLANT ..... Wm. B. Scaife & Sons Co.

HEATING SYSTEM
Type ..... Hot water, forced circulation
CLOSED HEATERS ..... Patterson-Kelley Co.
Capacity ..... 5000 g.p.m.
Temperature rise ..... 150 to 180 deg. F.
CIRCULATING PUMP ..... Allis-Chalmers Mfg. Co.
Capacity ..... 500 g.p.m.
Head ..... 50 ft.
CONDENSER PIT VENTILATING SYSTEM .. Buffalo Forge Co.
Capacity ..... 20,000 c.f.m.

TURBINE OIL FILTERING EQUIPMENT
BATCH FILTERS ... S. F. Bowser & Co., Inc.
CONTINUOUS PURIFIERS ..... DeLaval Separator Co.

INSTRUMENTS AND METERS
Gages and Thermometers ..... Foxboro Company
Load Indicators ..... El. Ind. Corp.
Draft Gages ..... Lewis M. Ellison
Temperature Recording Equipment ... Leeds & Northrup
Venturi Meters ..... Builders Iron Fdy.
Misc. Water Meters ..... Worthington Pump & Machinery Co.

DUCT WORK ..... Connery & Co., Inc.
DUCT INSULATION .. R. B. MacDonald Co.
BOILER SETTINGS ..... National Power Construction Co.
MISC. STEEL AND IRON WORK ..... Dauchy Iron Works

Water Circulation in Hot-Water Tank

I WAS MUCH interested in the answer to G. W.'s question on tank connections. I happen to live in a district that is supplied with very hard water that produces considerable liming and scaling. Under these conditions, the circulating pipe connections on the bottom of the tank as shown in both former illustrations, particularly when the water is maintained quite hot, would be conducive to maximum scale and sediment troubles. The accompanying sketch shows the method of connection that we have found best for our locality.

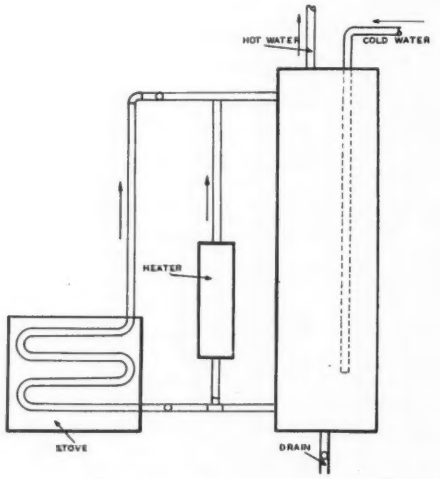
The circulating piping is connected into the side of the tank, the bottom return pipe being several inches above the bottom of the tank and the drain being placed at the bottom of the tank. This minimizes deposits in the circulating piping, giving the best utilization of the heat of the coil. I would prefer to omit the valves in the electric heater circulating line and install valves only in the stove coil line, if it is intended to isolate this section when the stove is cold and not in use. I believe that valves in circulating lines cause trouble and retard circulation, moreover they are unnecessary.

No hot-water delivery connection is shown in the illustrations mentioned, as it is assumed that the hot water is taken from one of the circulating connections. There is possibility of a short circuiting of the water through the circulating piping with delivery of rather cool water. In my sketch, the hot water is drawn from the top of the tank while the circulating tubes are connected to the top side of the tank, preventing such a condition.

I am also wondering how much is gained by utilizing the coil in the stove and whether it would not be economical to remove this coil entirely. Of course, while the stove is in use, water will be heated in the stove. But while the stove is cold, this coil will tend to dissipate heat to the stove and to the atmosphere in this section of the circulating system. Unless the stove is used a major portion of the 24 hours of each day, is the expense of changing the piping and moving the stove warranted?

Aside from these considerations, the corrected illustration given is undoubtedly the better.

Dayton, Ohio. F. M. REITER.



CONNECTION ABOVE TANK BOTTOM MINIMIZES DEPOSIT IN PIPE

Fiber Rope Testing Method

ON ACCOUNT OF the large volume of construction work which was handled in 1927 for the Philadelphia Co. and its affiliated operating companies by our Pittsburgh Branch, we found ourselves, at the beginning of this year, with a large supply of fiber rope on hand, varying as to size and condition. Nearly all of this rope had been used one or more times and much of it was soiled. As there is little salvage value in second-hand rope and as we are constantly using it in our work, the problem confronted us as to how we could make the best use of this rope and still do it without endangering our workmen. As a result of this, the method of testing each piece of rope and of marking it with a tag recording the test data, was developed. We were unable to find uniform or reliable published data on this subject hence it appeared necessary to develop original methods to meet our requirements.

Since nearly all of this rope is used in blocks, it was necessary to know the forces which would be at work when the ropes were so used. Two tests were made to determine these values. In the first, a set of steel blocks having a 1½-in. sheave diameter was used, while the

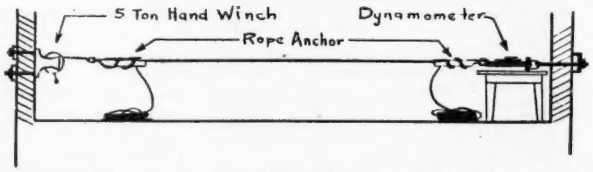


FIG. 1. ROPE TESTING SET UP—SAFETY GUARD SCREENS AT ENDS, NOT SHOWN

PITTSBURGH BRANCH

ROPE TESTING REPORT

SIZE ___ INCHES LENGTH ___ FEET.

DATE ___

TESTED FOR MAXIMUM SINGLE LINE PULL OF ___ LBS. ONLY.

TESTED BY ___ APPROVED BY ___

FRONT

SAFE LIFTING CAPACITY IN POUNDS OF VARIOUS SIZES OF ROPE AND BLOCKS

TOTAL NUMBER OF SHEAVES USED	SIZE OF ROPE IN INCHES								
	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8
ONE	215	400	625	895	1220	1600	2050	2500	3080
TWO	405	750	1170	1680	2300	3000	3840	4680	5700
THREE	580	1075	1675	2400	3290	4300	5500	6700	8200
FOUR	690	1280	2000	2870	3920	5100	6550	8000	9750
FIVE	770	1425	2200	3200	4360	5700	7300	8930	10800
SIX	810	1500	2340	3360	4600	6000	7680	9380	11400

REVERSE

FIG. 2. ROPE TEST REPORT TAG WHICH IS FASTENED TO EACH END OF ROPE TESTED AFTER DATA HAS BEEN FILLED IN WITH INK

second used a set of wooden blocks having a 3-in. sheave diameter. In the testing layout, the load end and the dead end of the rope were anchored to dynamometers and a fall line pull of 500 lb. was applied.

The load was applied at one end by means of a 5-t. hand winch fastened to a wall, the dynamometer resting on a table at the opposite wall to which it is fastened as shown in Fig. 1. The rope was anchored at the two ends, near the winch and at the dynamometer. Two operators were necessary. One man operated the winch while the other read the dynamometer. A screen was placed at each end to protect the operators when the rope broke. By varying the number of sheaves, the relation between the load and the dead end pull to the fall line pull was established.

Printed on the reverse side of the rope testing tags, Fig. 2 is a table giving safe lifting capacities for various sizes of rope and arrangements of blocks. These values are 40 per cent of the tested breaking strength of standard new rope. After the used rope has been tested a value 33 1/3 per cent lower than the actual test value is filled in with ink on the face of the tag with the other data and one such tag attached to each end of the rope tested.

Rope anchors, shown at Fig. 3, which are made in

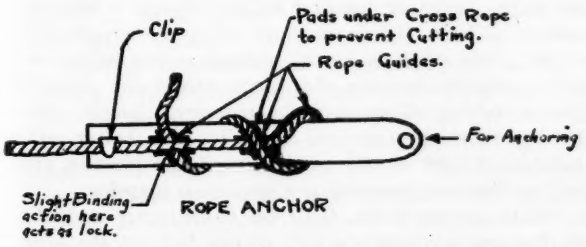


FIG. 3. ROPE ANCHOR FOR HOLDING "ENDLESS" ROPE WITHOUT SLIPPAGE OR CUTTING ACTION

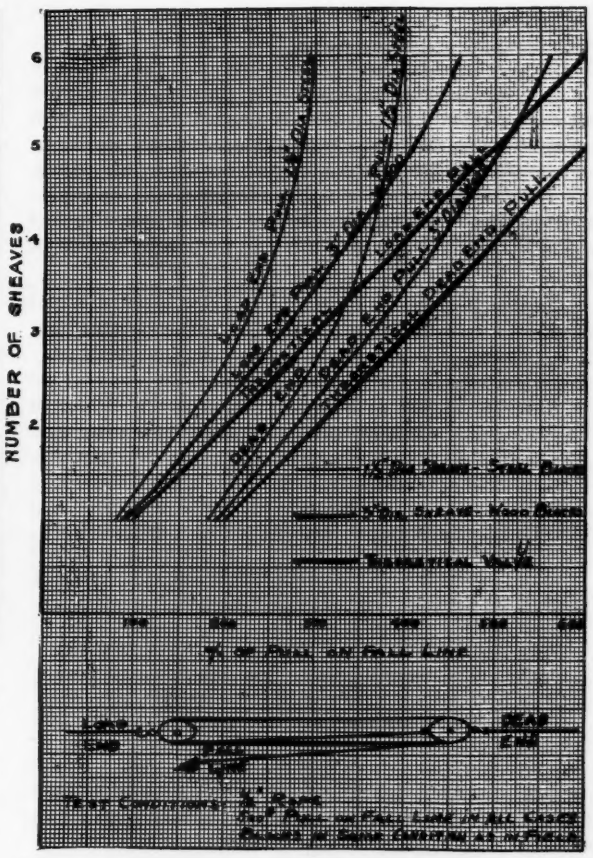


FIG. 4. CURVES SHOWING TEST DATA FOR VARIOUS LOADS AND NUMBERS OF SHEAVES ON BLOCK TEST

different sizes, were also devised to hold the rope in position at the anchor end and also at the dynamometer end, that would be the same as if the rope were operating in a rope block. These anchors hold an "endless" rope without any cutting action and all bends are designed to have the same radius as that of a sheave for that size rope. The lock binds the turns effectively.

Anchor pipe dimensions which are best suited to various rope sizes are:

2¼	in. dia. pipe for	3/8	and	1/2	in. rope		
3½	in. " " "	5/8	"	3/4	"	"	
5½	in. " " "	7/8	"	1	"	"	
8	in. " " "	1 1/8	"	1 3/8	"	"	

Curves Fig. 4, show the test data. The cost of making the tests based upon the methods described, averages about 2½ per cent of the value of the rope tested.

Pittsburgh, Pa. M. R. SUMMER AND G. E. BALCH,
Byllesby Engineering & Management Corp.

Failure of Fusible Plugs

FUSIBLE PLUGS, fitted in steam boilers, are not only liable to drop out through water shortage but may fail through corrosion of the plug.

Corrosion may occur on either the water or fire side of the plug, the former through the action of the boiler water and the latter through the action of the furnace gases. If the plug has been badly fitted or is cracked so that water can leak into the furnace, the water, coming in contact with the furnace gases, forms an acid solution

which quickly causes serious corrosion and in time will cause the plug to fail.

Furnace gases are always more or less corrosive when in contact with moisture. When dry, they do not cause corrosion, as moisture is needed to make them active. Corrosion on the water side is caused when the feedwater is highly alkaline or contains other impurities. The scale which forms over the plug may act as a protective coating and help to prevent corrosive action but in some cases it has been known to hasten corrosion through the impurities concentrated in it.

The body of the plug should be made of a metal suitable to withstand the action of the boiler water; not all metals are equally satisfactory when used with various boiler waters. This is particularly the case where the water is highly alkaline and it is essential that a plug be used in connection with it which can withstand this alkaline water, otherwise there may be serious corrosion between the threads of the plug and the core. It is to be recommended that the fusible core be renewed annually and that every two years the entire plug be removed and give the complete examination which is not possible when in position.

Brentford, England. W. E. WARNER.

Thermometer Indicates Combustion Changes that Save Coal

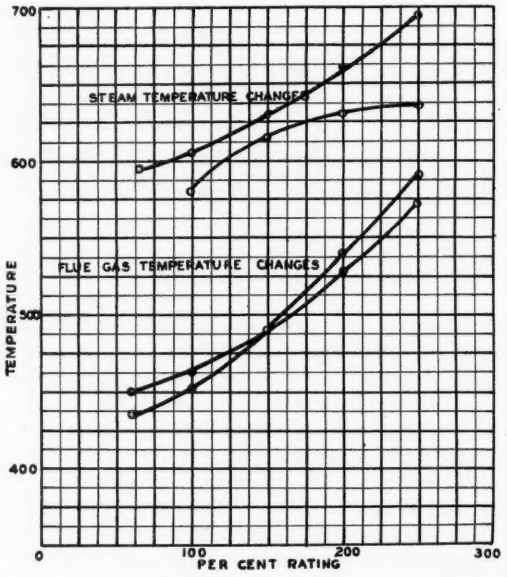
MANY ENGINEERS have definite opinions as to what instruments they need to operate their power plants efficiently. Of course many feel that a steam gage on the boiler is sufficient while some firemen feel that the installation of a CO_2 meter or flue gas thermometer is a personal affront and a direct challenge of their ability.

There is such a thing as having too many instruments, more than the personnel can care for or use. If any records are filed away on a peg each morning without further consideration, it is well to remove the instruments which make them, as unused or defective instruments establish a feeling of undependability in the mind of an operator that it is hard to break. Installed properly and introduced by one with suitable instructions for the force issued in a tactful way, instruments can do a world of good and save their cost many times over in the course of a year.

Of the many instruments in use, the steam thermometer probably receives less consideration from the average industrial plant operator than any other appliance. This instrument, installed in the steam line from the superheater, gives much information regarding boiler conditions if it is properly used. In large plants, especially in central stations, where they are working around 750 deg., the steam temperature is closely watched. Industrial plants do not have to watch the steam temperature for safety reasons as it is not often that they operate at such high temperatures, although the number of high-pressure, high-temperature industrial plants is increasing rapidly. Furthermore it was not until recently that superheaters came into general use for industrial plants and, since the temperature of saturated steam is definite for each steam pressure, a thermometer in the steam line would have been nothing more than a check on the steam gage.

When a boiler is working at a more or less uniform rate, a sudden drop in temperature of the steam leaving the superheater will probably mean that the water level is being carried too high and that the boiler has started to prime. If water is carried over into the superheater, heat which normally would be used for superheating the steam, would be used for evaporating the water carried over and the total temperature of the steam would of course be lowered.

Gradual drop in temperature below normal may mean, in a water-tube boiler, that the superheater coils are becoming covered with soot and need cleaning. In a fire-tube boiler, it may mean any one of several things; for instance a portion of the flues may be stopped up, thus short-circuiting the gases around the superheater. This can also happen with water-tube boilers if the first rows slag up unevenly, forming a partial baffle. Shifting or falling out of a baffle in a water-tube boiler may cause either a rise or reduction of the superheat depending upon the location of the superheater and baffle. Dirty boiler tubes and slagging will usually raise the total temperature because the boiler absorbs less heat than normally, the gases reach the superheater at a higher temperature and also have a higher velocity, both of which conditions tend to increase the heat transference in the superheater.



UPPER CURVES, COMPARED WITH THOSE BELOW SHOW HOW BETTER HEAT DISTRIBUTION IS SECURED BY BAFFLE CHANGES

Low CO_2, a symptom of large excess air usually coming through the fire will generally lower the total temperature by cooling the gases that reach the boiler tubes and as the boiler, at constant rating, absorbs a constant amount of heat, the gases must reach the superheater cooler. This effect is not as marked as one might expect, probably because the large excess air gives a greater volume of gas and the increased velocity over the superheating elements tends to give better heat transfer. Under certain conditions of stratification and baffling, the total temperature may even increase.

With varying loads, the total temperature and also the flue gas temperature will change but not the same for all boilers nor even the same for a given boiler under

different conditions of operation and baffling. To be of value, the total temperature reading must be used in connection with other simultaneous readings in which case it is of considerable assistance in guiding an experienced fireman. Not only must it be used with other simultaneous readings but the normal temperature for any rating must be found either by observing the data over a long period of time and drawing an average curve or, preferably, from boiler tests. Because of differences in construction, baffling and location of the superheaters, results from another installation cannot be compared with any degree of satisfaction.

Curves illustrated show the effect on the flue gas and on the total steam temperature caused by changing the baffles in a three-pass boiler with an interdeck superheater. Steam temperature increases are from 27 to 43 deg. Changes in the flue gas temperatures are not so evident and the change is only from about 17 deg. at 60 per cent rating to 22 deg. at 250 per cent. This rising temperature with increased load is a characteristic of the convection type superheater. A radiant type superheater has the opposite tendency, that is the total temperature or superheat decreases with increased load and as a constant or nearly constant temperature is desirable at all loads, the two types are sometimes combined in correct proportion to give this constant temperature.

Brooklyn, N. Y. F. PAUL.

Worn Parts Cause Pounding in Engine

NOT LONG AGO, an engineer of my acquaintance had a small vertical engine, used for driving a forced draft fan which pounded, the knock sounding as though the main bearing was very loose. He tightened it up but still the knocking continued. Finally after repeated tightening of the bearing, the babbit burned out and he came to me for help.

Fortunately the bearing had babbit liners and new ones could be obtained quickly. The new liners were then put in and adjusted. This was a hard job, in this particular engine, as the crank case is enclosed except for handhole plates which give access to the bearing. The bearing has bolts to hold the cap on and there are shims between the halves, so that it is difficult to get cap, shims and bolts in place without dropping something into the base which acts also as an oil reservoir.

After assembling and starting up the engine, the knock was still heard. Further investigation showed that one of the counterbalance weights was loose. The bolt which holds one of the counterweights to the crank cheek, had worked slightly loose and the hole, being slightly larger than the bolt, allowed the counterweight to drop away from the shaft when below it and towards the shaft when above. He said that the knock had been there for 2 yr.

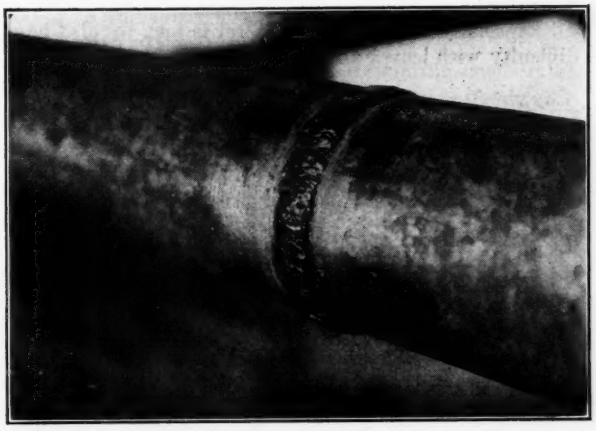
Another neighbor came to me one night to see me about a small blower engine that was giving him trouble. This engine had a Rites single arm inertia governor and was of the gridiron, slide valve type. He said that "she leaped and banged when she ran." The valve had a pressure plate covering it and the valve rod extended through it with nuts on each end of the valve to hold it in place and for adjustment. The rear end nut had worn a hole through the end of the valve so large that while the rod could pull the valve in the crank direction, it could not push it back.

The rod was threaded a greater distance than the length of the valve, so we put a washer on each side of the valve wall and an extra nut on the inside so that the nuts could be pulled up and hold the washers in place. The main governor pin and the hole for the pin in the flywheel were also badly worn. These were fixed for the time being by truing the pin and babbiting the hole. After making these changes, the engine ran smoothly. How that engine ran at all before making the adjustments is an unexplained mystery.

Minneapolis, Minn. FRED S. RUTLEDGE.

Bronze Filler Rod for Welding

USE OF BRONZE as a filler rod in oxy-acetylene welding has the advantages of uniformly low-melting point and easily controlled flow. A galvanized-iron water



BRONZE-WELDED, 6-IN. GALVANIZED IRON WATER PIPE

pipe, which has been welded with a high strength bronze known as Oxweld No. 21 is shown in the illustration. The weld produced is hard and resists wear well. It is understood that this rod has a tensile strength of 45,000 lb. per sq. in. and that it may be used for welding of brass, bronze and malleable and gray iron castings.

In the use of this filler rod, boiling and annoying fuming of the weld metal is almost entirely avoided, while gas and oxide inclusions are eliminated, thus resulting in a sound weld.

FIELD EDITOR.

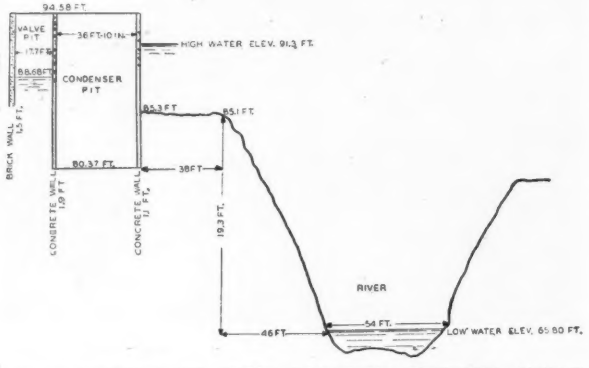
REPLIES MADE to a questionnaire sent out by the Bureau of Mines show that approximately 30 per cent of the total raw fuel used in the making of fuel briquets in the United States in 1928 was silt from coal-washing operations at mines, 23 per cent was screenings from dry preparation of larger sizes, 22 per cent was fines resulting from breakage in transit, 17 per cent was culm from banks at the mines, and 8 per cent was from other sources (Welsh anthracite, "river coal," screenings from wet preparation of larger sizes, and carbon residue from oil-gas manufacture). It is of interest that "river coal," dredged from streams which drain the Pennsylvania anthracite region, supplied all of the raw fuel for two briquet works and was used in combination with other raw coal by a third plant.

Questions and Answers

Pump Trouble Due to High Suction Head

OUR SOURCE of water supply for our power plant has a variation in water level of 25½ ft. as indicated in the sketch. Centrifugal pumps for circulating the water are located on the floor of the condenser pit. We frequently have difficulty, when the water level is low, to raise the water. What can be done to overcome our difficulty?

Especially when the water level is low, we also have difficulty with leaves and refuse from the river, clogging



CROSS-SECTION OF PUMP LOCATION SHOWING GREAT VARIATION OF WATER LEVEL

up our pipes. What is the best way to avoid this clogging? S. R. B.

A. Sketch of your condenser well and intake arrangement explains your condition clearly. Since the circulating pumps are located on the floor of the condenser pit, it is easy to see that you might have an excessive pumping lift when the river level is at its lowest point, this lift being, according to your sketch, about 15 ft. This should not be an excessive lift for pumps in good condition, although it is just about the maximum that should be attempted with centrifugal pumps to insure reliable and continuous operation. For the best conditions, it should be much less than 15 ft.

If you could build a pump pit outside of the condenser pit, going down possibly 10 ft. below the level of the condenser pit floor, you could lead a pipe or tunnel in from the river to the bottom of this pump pit and you would then have a lift of only a little over 5 ft. at the extreme low water level. This is probably the cheapest solution to your problem.

Although more expensive, a better solution would be to build a pit or sump below the low water level and use a vertical deep well pump to force the water from this pit. On account of the extreme variation between high and low levels, it would not be possible to locate this pit on the sloping bank of the river as it would then have to be made entirely watertight and that would be extremely expensive, if it could be done at all. The best way would be to lead a pipe in horizontally from the river below the low water line to a concrete watertight sump which would have to be sunk at least 15 ft. below the level of the condenser floor.

From this sump, the vertical deep well pump would force the water up. The sump would also provide a settling basin for sand but some method would have to be provided for cleaning it out after the sand had accumulated at the bottom. Unless you can build some kind of basin or sump in which sand can settle out in this way, it is difficult to see how you could eliminate trouble caused by it.

Regarding trouble from leaves and refuse in the river, probably the only thing you can do is to use good strainers on the end of the intake pipe with some provision for back washing them. Unless you can build a regular intake tunnel, it would be difficult, with your present layout, to use traveling screens, as these might be too expensive since they would have to be at least 15 ft. high.

If you are able to stand this expense, however, the problem would be easier to solve. You could simply excavate the channel from the river to the plant and the water would go through traveling screens to a well located behind them from which the pumps could take suction. This would involve the excavation of a channel over 20 ft. deep and about 75 ft. long and the construction of a concrete pit of the same depth and about 10 ft. wide.

Coil Capacity for Freezing Tanks

WHAT RULE or formula will determine the proper amount of coil to be used in an ice tank? A. M.

A. Variable factors involved in this determination are (a) plant water condition, (b) back pressure, (c) rate of brine circulation, (d) design of coil system, (e) rate of flow of refrigerant through coils and (f) amount of liquid refrigerant in coils.

Determination of the amount of coil necessary may be made by use of the following formula:

$$A = (288{,}000 \times 1.6) \div (T \times 24 \times C)$$

where A = area of coil surface in square feet per ton of ice

T = average difference in temperature between the brine and the refrigerant

C = coefficient of heat transfer from the brine on the outside of the pipe to the refrigerant on the inside.

Unfortunately, C is mainly a factor of ignorance. It may vary anywhere from 20 to 120 depending upon the velocity of the brine, the flow and condition of the

refrigerant, the design of the coils and the back pressure.

For the average coil of 1½-in. pipe, we probably shall be safe in taking 25 B.t.u. per sq. ft. of surface per degree F. per hour as a safe value for C, while in a new herringbone system or multiple header design we might safely go to 100 B.t.u. per sq. ft. per deg. F. per hr. During the past year, some very good work has been carried on by several manufacturers and the efficiency of the coils at the bottom and top determined. It has been not uncommon to find over 100 per cent difference in the effectiveness of the coils at different points in the system.

With a 12-deg. F. brine temperature in an ice tank, which would give about a 43-hr. freezing time with 300-lb. cans and with a suction pressure of 20 lb., approximately 320 lineal feet of 1¼-in. pipe per ton of ice, in an old type coil system, would be required. The same results would be obtained with an 18-deg. F. brine and a 60-hr. freezing time with the same number of lineal ft. of pipe and a 25-lb. back pressure. On the other hand, the number of lineal feet of 1¼-in. pipe could be reduced to 170 with 12-deg. F. brine by using a suction pressure of 15 lb. or with 18-deg. F. brine by using a 20.7-lb. suction pressure.

Load Distribution Among Steam Units

OUR ENGINE is a 350-hp. slide valve engine operating at 120 lb. steam pressure. Our turbine is a 375-kv-a. mixed pressure turbine, that is, it can be operated either from the exhaust of our engine or directly from the steam mains. In either case. the steam enters the receiver and goes into the turbine between 5 and 10 lb. pressure.

On a load of 200 to 300 kw., is it more efficient to operate the turbine alone or to use the engine as a pressure reducer and get what power we can out of the steam between the 120 and 10 lb. pressures and also get what we can out of the turbine from 10 lb. pressure down to say 26½ in. of vacuum? M. H. M.

A. At first glance, it seems that it would be more economical for you to operate your turbine condensing at partial load, say at three-quarters load and with steam at 120 lb. pressure, than it would be to use the engine and exhaust into the turbine. The reason for this is that, although you would increase the economy of the engine about 25 per cent by combining it with the turbine, the total steam consumption of the combination would be about 30 per cent greater than the steam consumption of the turbine alone at three-quarters load.

Of course, there is one way in which you can determine what the best combination is, provided you have a steam flow meter or preferably two of them, that is, by putting flow meters on the steam lines leading to both engine and turbine. In this way, you can experiment with the combination to find out which arrangement takes the least amount of total steam for a given electrical load. Personally, I think that the latter method would be much better in every way than any amount of calculation because calculations involve assumptions as to the mechanical condition of the engine and turbine, assumptions of water rates and other inaccuracies.

I assume that you are aware of the fact that with full electrical load on both turbine and engine, the most economical combination is that which uses the exhaust from the engine into the turbine and this case concerns itself only with light loads.

Assuming that your engine is in fairly good condition, your water rate for condensing operation should be between 35 and 50 lb. for three-quarters load. Operating the engine condensing, you might, under very good conditions, get it down as low as 25 lb. per kw-hr. You have not stated what type of engine you have and these rates may run much higher. At full load, the water rate of the combination might be somewhere between 30 to 40 lb. per kw-hr. but at partial load, it would be considerably higher. The water rate of the turbine alone operated condensing at part load would probably not be much over 30 lb. per kw-hr. If the turbine is in fairly good condition you would, of course, get better results with superheated steam but the figures given above will be relatively as shown. It is evident, therefore, that the condensing turbine at part load will probably give you lower steam consumption than any other combination of the two units.

You will understand that, in estimating such water rates, a great many assumptions have to be made concerning the mechanical condition of the units, the average load factors and a dozen other things. That is the reason I suggest getting the answer by use of a steam flow meter which method takes into account all these variables.

By far the best method for you to follow is to measure the steam consumed under different assumed conditions by means of steam flow meters and then select the best combination. Some discussion of this point is given in the following books: Power Plant Engineering data book entitled, "Steam Engines, Turbines, Condensers, Pumps," pages 46 to 52; Gebhardt's "Steam Power Plant Engineering," pages 395 to 428 and Fernald and Orrok's book on "Engineering of Power Plants," page 52.

Priming, Foaming and Corrosion of Boiler

WHAT CAUSES priming, foaming and corrosion in a boiler and what may be done to avoid these troubles?

J. W. M.

A. Priming is the pulling over of water with the steam due to intense overload or excessively rapid steaming. It is best remedied by reducing the load.

Foaming is due to impurities in the water. These impurities boil to the surface, therefore, if a surface blowoff is available, it will help relieve the situation. It is well also to open up the bottom blowoff and feed in a fresh supply of water in order to reduce the density.

Corrosion is due to acidity of the water or to oxygen in the water. If the water is acid, it is best to get another source of supply. If oxygen is causing the trouble, deaerate the supply or use some mixture that will absorb the free oxygen.

JUNE SHIPMENTS of domestic water softeners, as reported by 20 manufacturers to the Department of Commerce, were 1228 units, with a net sale price of $142,305, as compared with 1444 units in May, with a net sale price of $160,532.

Editorial Comment

Business in the Next Census

How to make the census to be taken next year of greatest use to business is the problem that is being solved by an Advisory Committee on Manufacturers appointed by Secretary Lamont with Colonel L. S. Horner, president of the Niles-Bement-Pond Co., as chairman.

Besides the count of population, manufactures, agriculture, mining and distribution, it is, for the first time, sought to obtain data of the most practical value to business men in studying markets and planning for the future. To further this purpose, the Advisory Committee will determine what questions are to be asked, limiting them to such as will give data of practical value to manufacturers, and will decide what tabulations should be made to have the greatest value to business men.

Conferences will be held with industrial organizations and with representatives of each industry to formulate schedules adapted to that industry. The Committee has decided to recommend a complete census of business, covering all plants, regardless of size. For the smaller plants, the records will be gathered by the population enumerators while larger plants will be covered direct from the Division of Manufactures of the Census Bureau.

Obviously, the value of the results will depend on the co-operation of manufacturers in furnishing promptly the reports asked for. While this may involve some effort, the value of complete and accurate data, designed to be of greatest use to manufacturers and business will more than repay the effort. The Census Bureau is endeavoring to coöperate with business men to give them the greatest assistance possible and should have hearty coöperation in return.

Developments at Cahokia as a Guide to Plant Rehabiliation

Probably no power plant development in recent years means more to the power plant industry as a whole than do the recent changes made at Cahokia in connection with the installation of the new 75,000-kw. unit.

New developments are, as a rule, not easily applied to existing plants without excessive cost, which usually makes it advisable to build a new plant and either scrap the old one or use it as a standby.

Since the first section of Cahokia was built, furnace water walls and a better understanding of condenser design have practically revolutionized practice along these lines, while extraction of steam for heating feedwater to temperatures approaching saturated steam temperatures in the boiler drums is standard practice and double-winding generators have been developed to facilitate switching and handling the enormous current output of large generators.

All of these developments have been taken advantage of at Cahokia and in addition another new development in condenser construction has been utilized for the first time to meet the foundation limitations imposed by the piling upon which Cahokia is built.

Four of the original furnaces have been rebuilt with water walls to generate twice as much steam as they were originally designed for. One of the 35,000-kw. turbines has been removed and a new 75,000-kw. unit installed in the same space. By using a double-winding generator and the emergency bus, the same switch gear is used to handle practically double the output. The same condenser could have been used but this would have necessitated the purchase of a new condenser to use with the old turbine which was moved to Venice Station, so it was thought better to purchase a new condenser of practically the same size but especially designed for the new unit.

Cahokia is built entirely on made ground and the increased weight of the new turbine would have overloaded the piling under the foundation. To overcome this difficulty, the condenser is built with two expansion joints and the condenser shell and circulating water are carried independently of the turbine foundation by two transverse girders. This also gives a constant downward pull on the turbine exhaust regardless of vacuum changes.

To those interested in rebuilding old plants, however, the heat balance of the new unit is of particular interest. Originally, condensate from the 35,000-kw. units Nos. 1 and 2 was heated by one bleeder heater and the exhaust of a house turbine to about 210 deg. In the revised layout, condensate at about 150 deg. F. from the old No. 2 unit joins that of the new No. 1 unit just ahead of the new low-pressure heater and is heated to a final temperature of 315 deg. F.

New practice and developments applied to new plants indicate the progress of the industry but the application of these practices and developments to present plants requires considerably more ingenuity and is of greater present value to the industry as they allow the economical rehabilitation of plants which, although not obsolete in the sense that they can be scrapped, are still far below present performances.

Power Consumption in Foreign Countries

Electricity is widely used in Europe but a recent survey shows that the per capita consumption, even in those cities using electricity most widely, is far below that of the leading cities in this country.

For instance in both Basel, Switzerland, and The Hague, Holland, the houses are 100 per cent wired but the kilowatt-hour consumption per capita is only 640 and 209 respectively as compared with 1088 kilowatt-hours for Chicago which is reported as 96.3 per cent wired.

Judging from the report, considerable difference is found in European countries; for instance, both the Swiss and Holland cities are shown as nearly 100 per cent wired but the per capita consumption of power in Switzerland is about three times as high as in Holland. Other European cities are shown wired as follows: Copenhagen 89.8 per cent; Stockholm 88.8 per cent; Paris 63.8 per cent Budapest 56.6 per cent and Berlin about 50 per cent.

Per capita consumption shows even a wider variation ranging from 640 kw.-hr. for Basel to 135 for Budapest with other cities as follows: Stockholm 295; Paris 279; Berlin 252; Copenhagen 195 and London 151 kw-hr.

Abundance of well-developed hydroelectric projects accounts in a large measure for the high consumption of power in Switzerland while the tremendous strides made in increasing the efficiency of fuel burning plants in this country has been an important factor in bringing the cost of power to a point where the per capita consumption is no longer of major importance to the user.

The value of this increased efficiency is perhaps more apparent if the fuel used is considered in relation to the electrical output. For instance, a pound of coal produces almost twice as much power today as it did in 1919. Roughly the public utility plants burn 45 million tons of coal annually. This figure is increasing slightly but the change since 1920 has been less than ten per cent. Production of power on the other hand has almost doubled and if power were being produced today at the same efficiency as in 1919 the coal consumption would be 85 instead of about 45 million tons annually. It has been estimated that based on 1919 figures, improvements in power generation facilities has saved the country 180 million tons in nine years.

Of course this saving was made possible by increased consumption, better load distribution and interconnection, but the increased load was brought about by lower rates so that the growth of the generating facilities, efficiencies and increased consumption are mutually interdependent.

When we realize that cutting the per capita consumption from around 1000 down to 100, 200 or even 300 kw-hr. per year would take us back a few years to where rooms were semi-illuminated by one lamp in the center of the room, where lights were religiously turned off in vacant rooms and electric appliances of all kinds were too expensive to use, it is a trifle easier to visualize what 400 or 500 kw.-hr. annually means in the way of comfort.

Manufacturing Flue Gas

Ordinarily we do not think of a waste product like flue gas as being manufactured but in the power plant it has been demonstrated that the highest efficiency of combustion and heat absorption are obtained when the most perfect flue gas, both as to temperature and chemical constituents, is obtained. Needless to say, this product varies with the quality of the raw materials used, the proportions put together and the conditions of the manufacturing process. What may be perfect flue gas in one plant, or even one boiler in a given plant, may be far from a perfect product for another plant or boiler.

Probably the most difficult problem the engineer charged with the operation of a steam plant has is that of ascertaining what the chemical analysis and temperature of his flue gases should be for the varying load conditions, different grades of fuel used and varying conditions of the boiler heating surfaces. Nothing short of a series of tests conducted under operating conditions will give the answer to the problem. Once, however, the proper analysis has been established, the problem of the operator then becomes similar to that of manufacturing any gas—the ingredients must be supplied in the proper proportions and carefully mixed under accurately controlled temperature conditions.

Where efficiency of combustion is highly essential, means must be provided whereby the operator will know whether or not proper proportions and conditions are being maintained and, if not, whether more or less air is required to reestablish correct conditions. Such means are available though not as extensively installed as they should be and in many places where they are installed, the significance of their indications is not thoroughly understood. The problem is complicated but it is hoped that the article on other pages of this issue by W. N. Polakov will aid in making boiler instruments real interpreters of conditions.

Of course we do not aim to manufacture flue gas in a steam generating plant but, like the work of a detective in hunting criminals, a study of flue gas conditions will aid in discovering the places where heat units are escaping.

Is Boiler Horsepower an Obsolete Term?

Boiler horsepower is an arbitrary standard which, although now fairly well standardized, has been the subject of much controversy. It bears no fixed relation to the amount of work or to the term horsepower as applied to a prime mover.

During the Centennial Exposition at Philadelphia in 1876, a boiler horsepower was considered to be the evaporation of 30 lb. of water into steam at 70 lb. gage when using 100 deg. feedwater. This was known as the Centennial rating. To take care of the higher pressures and get a common standard, the A.S.M.E. adopted the definition of 34.5 lb. of water into steam from and at 212 deg. F.

In order to bring boilers under this rating or a basis of size, manufacturers agreed to a nominal rating of 10 sq. ft. of heating surface per boiler horsepower. Previous to this agreement all manufacturers used different ratings which through custom had become somewhat standardized at 10 sq. ft. for water-tube boilers, 12 sq. ft. for tubular boilers and 8 sq. ft. for Scotch Marine boilers.

Obviously, such an arbitrary term is of small value in modern plants where fires are forced to rates of combustions six and seven times that formerly thought possible. For this reason, it is becoming customary to use the terms square feet of heating surface and output in thousands of pounds of steam per hour.

With the wide variation in steam pressures now in use the actual output of a boiler in pounds is not a measure of the heat absorbing capacity of the boiler. Recognization of the term K.-B.t.u., the heat transfer in thousands of B.t.u. per hour per square foot of boiler, superheater and economizer surface, as used by the Prime Movers Committee of the N. E. L. A., would be as big a step toward standardization as the adoption of the original Centennial Rating in 1876.

Power Plant Engineering Developments and News

World's Largest Transformers

STRENGTHENING of bridges and the lowering of railroad tracks 18 in. at one point to permit clearance are necessary to transport the four largest electric power transformers ever built from the Westinghouse Electric and Manufacturing Co. plant at Sharon, Pa., to Roseland, N. J., near Newark.

These transformers will be used to transfer power at the Pennsylvania Power and Light Co.'s plant at Bushkill, Pa., to the Public Service Electric and Gas Co.'s system in New Jersey. Fifty-six freight cars will be necessary to carry the transformers and parts over the Erie Railroad.

An army of men, almost equal to that required to move a three-ring circus, is required to load and prepare the huge transformers for shipment. Each transformer is 35 ft. high, weighs approximately 300 t. and requires a floor space 22 by 23 ft. More than three tank cars of oil, or 32,000 gal., will be required to fill each transformer.

The transformers are rated at 220,000 v. but were tested at 570,000 v., the highest test voltage ever applied to a power transformer. The core and coils in each transformer contain 63 t. of laminations and 15. t. of copper windings. There are more than 32 mi. of wire in the copper windings in each transformer.

Winding capacity of the four transformers is sufficient to furnish power to illuminate 6,000,000 40-w. incandescent lamps, the kind most popular in home illumination, or a total of approximately 200,000 ordinary six-room houses, or all the homes in a city larger than Cincinnati, O.

The weight of each transformer, as prepared for shipment, is 270,000 lb., one of the heaviest individual units ever shipped on single railroad cars. It was necessary to utilize a special depressed type of equipment to permit clearance under vehicular and cross line bridges along the right of way. To meet the requirements further, the tracks at Caldwell, N. J., will be temporarily lowered 18 in. to permit clearance.

In addition to the four special depressed cars, 18 well type cars, 14 gondolas, six ordinary flats and 14 oil tank cars will be necessary to handle the consignment, the hauling of which will be done by one of the Erie's new heavy traffic locomotives.

Each transformer was packed in a specially designed shipping tank. In order to meet the loading requirements of the Erie Railroad, the oil was drained from

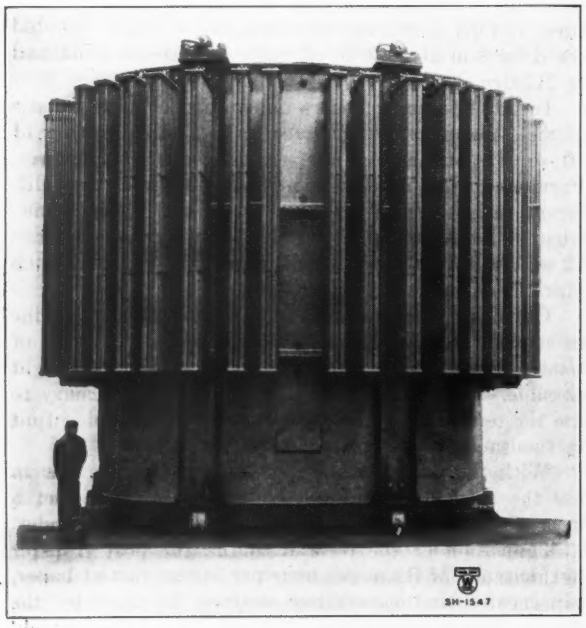


FIG. 1. ONE OF THE LARGE TRANSFORMERS COMPLETE SHOWING COMPARATIVE SIZE

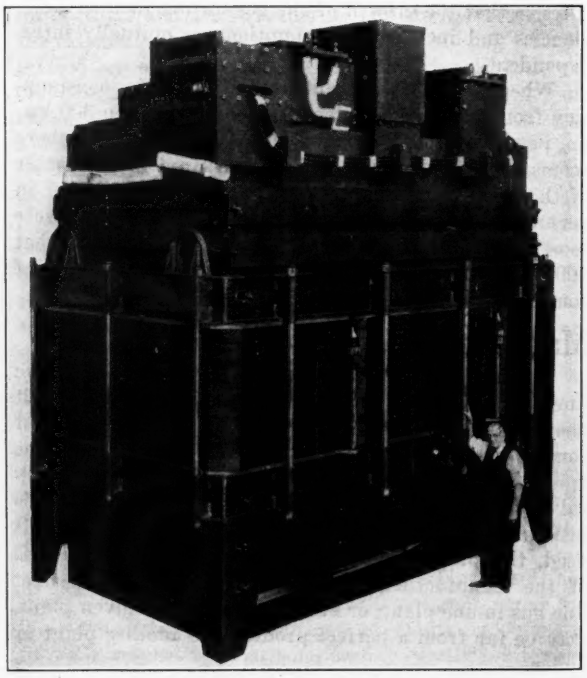


FIG. 2. THE CORE AND WINDINGS OF ONE OF THE TRANSFORMERS

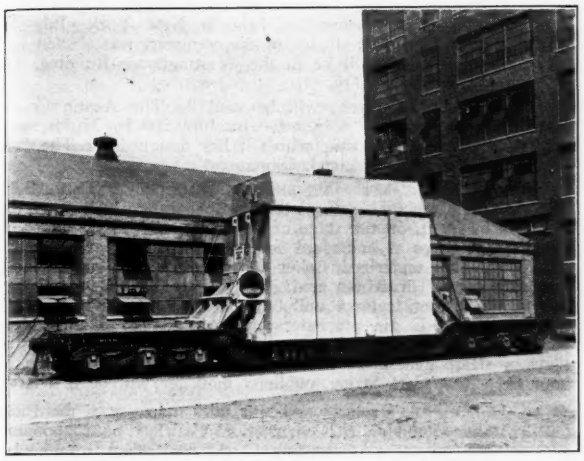


FIG. 3. ONE OF THE TRANSFORMERS ON THE SPECIALLY BUILT RAILROAD CAR

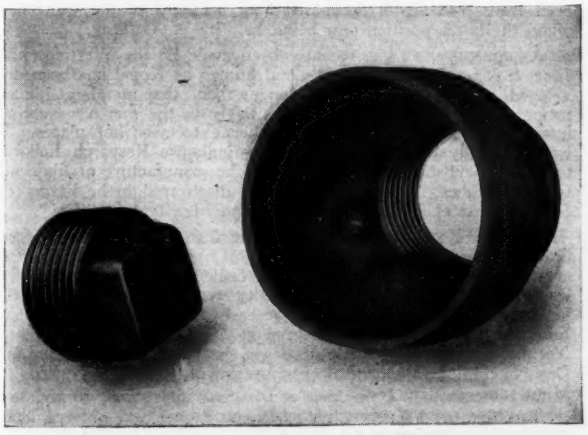
the transformers and the shipping tanks were filled with dry nitrogen gas to preserve the insulating qualities of the coils in transit.

The huge transformers will be located at the Northeastern end of the 220,000-v. system which joins the systems of the Pennsylvania Power and Light, the Philadelphia Electric and the Public Service Electric and Gas Cos.

Minute Emergency Expansion Plug

PLUGGING BOILER tubes which develop sudden leaks while boilers are in operation is often resorted to as an emergency measure to keep the boiler in operation until the tube can be replaced. For such a purpose the Minute Emergency Expansion Plug shown herewith has recently been placed on the market by E. J. McCarty Machine Works, Clinton, Mass. Construction of the plug is shown in the illustration.

To expand it into the end of the tube, the center plug that threads into the main plug is removed and the plug is tried for size, as it should fit snugly into the tube so that it will not turn when it is being rolled in. An ordinary tube expander can then be inserted with its spindle through the small hole and the plug can be expanded into the end of the tube. Then the center plug, which has a tapered thread, is threaded into place again.

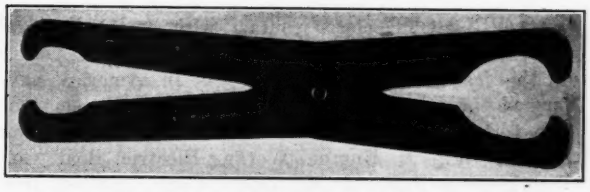


BY REMOVING CENTER PLUG (SHOWN AT RIGHT) EXPANDER CAN BE INSERTED TO ROLL LARGE PLUG INTO TUBE END

These plugs are designed to withstand a hydrostatic pressure of over 400 lb. per sq. in. and are made in standard sizes for tubes from 2 in. to 4 in. Special sizes can be furnished, however, if necessary.

Ideal Fuse Pullers

IN THE REMOVAL of blown fuses, utmost caution is desirable. Not only is there the possibility that the switch may not be out or that the fuse may not be blown, but improper removal is likely to impair the clips. Often the greatest cause for premature fuse blowing is loose clips. Prying out fuses with a screwdriver or stick or jerking them out with cautious, unsteady fingers is likely to bend the clips, thereby causing heating when current is again applied, thus annealing the clips and rendering them useless.



GIANT SIZE FUSE PULLER

With these points in mind, the Ideal Commutator Dresser Co., Sycamore, Ill., is offering a full line of fuse pullers made up of laminated horn fibre, giving plenty of jaw surface and mechanical strength for removing fuses from the tightest of clips, with a straight steady pull and with complete safety, even though the fuse might by chance be alive.

The Ideal line of fuse pullers covers four sizes, as follows: Midget size, for handling small fuses, grid leaks, etc.; Pocket size, for fuses 0 to 200 amp., 250 v. and 1 to 100 amp., 600 v.; Giant size, for fuses 100 to 600 amp., 250 v., and 60 to 400 amp., 600 v.; Jumbo size, for fuses 200 to 800 amp., 250 v., and 200 to 600 amp., 600 v.

Type RR Reverse Current Relay

FOR USE in connection with a suitable circuit breaker, having under-voltage or shunt-trip coil, Roller-Smith Type RR relays have been recently developed to give protection against reversal of current. Their principal applications are in battery charging work and for the protection of two or more generators running in parallel.

Type RR relay is rectangular in shape, the overall dimensions being approximately 4 by 6 in. by 2⅛ in. deep. Connections are in the form of rear studs (of which there are four). The finish is black rubberoid; the mechanism is protected by a metal cover, removable from the front.

Relay mechanism consists of two series coils mounted on iron cores which act upon a polarized armature. This armature is pivoted and carries on one end a contact point which controls the external tripping circuit. The series coils are connected directly in series with the circuit which is to be protected.

Two terminals for the external tripping circuit are insulated from the relay proper. When there is a reversal of current, reaching a value not less than 5 per cent of the relay rating, the armature quickly moves and, in doing so, closes (or opens, as the case may be) the contacts connected to the external tripping circuit.

Action of the Type RR Relay is quick and positive. The contacts are designed to handle a current of 2 amp. at 220 v. These relays are available in capacities of 3, 5, 10, 15, 20, 30, 45, 60, 80, 100, 150 and 200 amp. They are made by Roller-Smith Co., 233 Broadway, New York.

Diesel Engine Manufacturers Form Association

TO PROMOTE closer contact with each other and with the problems of the Diesel engine user, twelve of the leading builders of Diesels in America have formed the Diesel Engine Manufacturer's Association. The following are members of the association: New London Ship & Engine Works, Electric Boat Co.; Worthington Pump & Machinery Corp.; Fulton Iron Works Co.; Ingersoll-Rand Co.; Fairbanks, Morse & Co.; Nordberg Manufacturing Co.; I. P. Morris & DeLaVergne, Inc.; Winton Engine Co.; Cooper-Bessemer Corp.; McIntosh & Seymour Corp.; Busch-Sulzer Bros. Diesel Engine Co.; Hooven, Owens, Rentschler Co.

Henry R. Sutphen, president, Electric Boat Co., is president of the association; E. T. Fishwick, vice president of the Worthington Pump & Machinery Co., is vice president of the association; and Harlan A. Pratt, manager oil and gas engine department of Ingersoll-Rand Co., is secretary and treasurer. The association also employs M. J. Reed as research engineer, with headquarters at the association office, 30 Church St., New York City.

News Notes

FALL MEETING of the American Welding Society will be held at Cleveland, Ohio, Sept. 9 to 13, in the Hotel Statler and the Public Auditorium. Six technical sessions will be held, the papers presented covering Welding in the Manufacture of Electrical Machinery, Steel Parts to Replace Castings, Welding of Copper, Its Alloys and Aluminum Alloys, Methods of Testing Welds, Welding of Boiler Tubes and Drums of Thin Sheets and of Pipe Lines in the Field, Welding of Steel Buildings.

Meetings of the American Society for Steel Treating, of the Iron and Steel Division of the Institute of Mining & Metallurgical Engineers and of the Institute of Metals Division of the American Society of Mechanical Engineers will be held in Cleveland also during the week of Sept. 9, with an exhibit in the Auditorium of Machinery for working every kind of metal covering 80,000 sq. ft. of floor space.

FRANK M. GENTRY, formerly assistant to mechanical engineer, The New York Edison Co. and for many years principal assistant engineer with Geo. A. Orrok, consulting engineer, has resigned from The New York Edison Co. to jojn the staff of Lehman Brothers, bankers, of New York City.

HAHN ENGINEERING Co. has appointed as agents Neville & Cleary, Candler Bldg., Atlanta, Ga., and Garrett Burgess, Inc., 5050 Joy Road, Detroit, Mich.

AT A MEETING of the Board of Directors of the Westinghouse Electric and Manufacturing Co. held in New York, July 31, Harold Smith, General Solicitor of the company, was elected vice president. His office will be in the Westinghouse Building, 150 Broadway, New York City.

ELECTRIC ARC WELDING will be used by The Austin Co. in fabrication and erection of a new structure 200 by 110 ft. with a 65-ft. span traveling crane which it has designed for The Lincoln Electric Co. at Cleveland, Ohio.

AT THE N. A. P. E. CONVENTION, Chattanooga, Tenn., Sept. 9 to 14, the Combustion Engineering Corporation will occupy a space 80 by 20 ft. on the stage of the Memorial Auditorium with exhibit of a Type E underfeed center retort stoker and a newly developed small underfeed stoker for buildings and small plants, including forced draft fan and electric drive, both in full size equipment. Other features will be models of h. r. t. boiler, C-E fire furnace, C-E air preheaters and sections of drums, high-pressure heater elements, fittings and wall panels showing installations of steam generating of 200 hp. up to 800,000 lb. steam an hour capacity. Carl Stripe, publicity manager will be in charge.

W. H. ARNOLD, formerly assistant sales manager of the Pittsburgh Valve, Foundry & Construction Co., has been appointed general sales manager, succeeding C. A. Anderson, Jr., who became president of the company on March 1.

ACCORDING to a recent announcement, the Aluminum Co. of America is planning the development of hydroelectric projects in the mountains of North Carolina and Tennessee. A total of eight projects are under consideration, the cost of which will amount up to $125,000,000. Seven of these projects will be in western North Carolina and the other in Tennessee. One of these plants, it is stated, will be located at Fontana on the Tennessee River, two others near the junction of the Tennessee and Tuckaseegee rivers, one at Needmore and one at Aquones.

ANNOUNCEMENT comes from The Jeffrey Mfg. Co., Columbus, Ohio, that C. W. Miller has tendered his resignation as treasurer of the company but will continue as a member of the board of directors. His place as treasurer will be taken by H. Supp, Jr., formerly credit manager. J. X. Farrar, formerly assistant purchasing agent has been appointed credit manager. The Ohio Malleable Iron Co., a subsidiary of The Jeffrey Mfg. Co., recently elected W. A. Grieves as secretary and H. Supp, Jr., as treasurer, both men having similar positions with The Jeffrey Mfg. Co. J. F. Davidson has been elected to the board of directors of the Ohio Malleable Iron Co.

CHICAGO PUMP Co. announces that Sprekelmeyer-McDonald Co., Ft. Worth, Texas, has recently been appointed its representative in that territory.

J. R. JEFFREY, who for 28 yr. has been associated with engineering work of the Allis-Chalmers Mfg. Co., Milwaukee, Wis., has recently resigned from the position of manager of the electrical engineering department and plans to retire completely from engineering work. To succeed Mr. Jeffrey, R. S. Fleshiem has been appointed as manager of the electrical department, having served the company almost successively since his graduation from the University of Michigan in 1904. L. W. Grothaus, assistant manager of the electrical department of Allis-Chalmers Mfg. Co., has been transferred from the company's Bullock Works at Norwood, Ohio, to Milwaukee to succeed Mr. Fleshiem. C. J. Rattermann has been appointed assistant manager of the electrical department of the company and will be located at the Norwood Plant, having been transferred from the position of manager of the Cincinnati office, the latter position now being held by W. G. May.

ANNOUNCEMENT has recently been made by the Westinghouse Elec. & Mfg. Co. that a new metal known as Konel has been developed, that, it is claimed, is stronger than other metals at higher temperatures and can be used extensively in the moving parts of internal combustion engines and other extremely hot places. It was originally developed by the Westinghouse Research Laboratories as a substitute for platinum in the manufacture of filaments for radio tubes. The new metal was discovered to be harder to forge than steel and to be very tough at high temperatures.

JOHN E. NICHOLAS has been appointed to conduct rural electrification research work in the School of Agriculture and Experiment Station of Pennsylvania State College. Mr. Nicholas, who was graduated from Lehigh University in the mechanical engineering course, was employed several years by the Bethlehem Steel Co. Later he took his master's degree at Massachusetts Institute of Technology and, for the past 3 yr., has been employed in the Department of Mechanical Engineering at the University of Minnesota.

THE SOCIETE D'ELECTRICITE DE PARIS, France, has ordered from the Oerlikon Company for the extension of its St. Denis power station a 75,000-hp. high-pressure steam turbine. This will probably be the first instance of the generation of such high power in a multi-cylinder set arranged on one shaft and running throughout

at a speed of 3000 r.p.m. The set will consist of a high and a medium pressure element and two low-pressure cylinders coupled direct to one 50,000-kw. alternator and an exciter, all mounted in line on a single shaft. During normal working conditions, the steam pressure, measured immediately in front of the turbine, will amount to from 710 to 850 lb. per sq. in. abs., while the steam temperature will range from 842 to 900 deg. F. In exceptional cases, the turbine must be capable of withstanding a pressure of 995 lb. per sq. in. and a temperature of 932 deg. F.

In Delray Power House No. 3, fire was lighted under boiler No. 5, for the first time on July 8 and under boiler No. 3 on July 25. These two boilers will supply the steam for the first main unit in the station. Turbine No. 11, which is a 50,000-kw. unit, was turned over for the first time on July 15 and with its auxiliaries is now contributing to the Detroit Edison Co.'s power system. All building work on the first units has been completed and turned over to the production department. Work on boilers Nos. 2 and 5 is in progress and the drag line system for handling and storing water borne coal is completed.

The Ashton Valve Co., Boston, Mass., announces that the following agencies recently have been appointed representatives of the company: The Smiley Equipment Co., Kansas City, Mo.; The Consulting Engineering Co., Pittsburgh, Pa., and Williamson & Woody, Richmond, Va.

Announcement has recently been made that W. G. Jens, formerly manager of the Pittsburgh branch of Byllesby Engineering and Management Corp., has been appointed operating manager of the Duquesne Light Co. at Pittsburgh. A. G. Butler, formerly general superintendent of construction of the Louisville Gas & Electric Co., Louisville, Ky., succeeded Mr. Jens as manager of the Pittsburgh branch of the Byllesby Engineering and Management Corp. Mr. Butler will be succeeded by G. R. Armstrong who has been assistant superintendent of construction in Louisville since 1922.

Wisconsin Valley Electric Co. is now rebuilding the Jersey Dam located near Tomahawk, Wisc., and expects to have the work completed by the first of November. The new dam will be 152 ft. long and will connect with the hydroelectric power station which is 52 ft. long and has a capacity of 452-kw.

Incorporation under Dominion charter has recently been effected by the Direct Steaming Co. of Canada, Ltd., whose office is at Kingston, Ont. Its principal activities will be the installation of Direct Steaming systems and related power plant equipment at locomotive terminals in Canada. By agreement with the Railway Engineering Equipment Co. of Chicago, the Canadian company will control construction of all future installations of Direct Steaming systems in that country. Officers of the new company are William Casey, President; S. C. Holland and G. P. Bogert, Vice Presidents; J. M. Hickey, Secretary, and G. W. Daly, Treasurer.

Orange, Iowa, Electric Co., a farmer-owned distribution system which serves 31 residents in Orange township, has been sold to the Iowa Public Service Co. from which it has been buying power wholesale the last 9 yr.

M. J. Whittall Associates, Worcester, Mass., plan to build a new steam power plant to cost about $400,000. The plant will be designed and constructed by Francis J. Sill, consulting engineer, Westboro, Mass.

Catalog Notes

Roth-Perkins Windmill Generator, designed for capacities of 1 kw. and 2½ kw., is described in a recent circular issued by Roth Brothers & Co. (Division of Century Electric Co.), 1400 West Adams St., Chicago. One of the features of this generator is that it uses an airplane type propeller instead of a wheel with many blades. This propeller drives a generator that charges a storage battery, the entire apparatus being under automatic control depending on the wind velocity.

Aquagel, a plasticising, waterproofing and strengthening agent for cement, mortar and concrete, is described in bulletin No. 103, a 12-page, illustrated publication of Silica Products Co., 700 Baltimore Ave., Kansas City, Mo. The bulletin describes the method of using Aquagel and discusses the chemical and mechanical characteristics of the various cement mixtures employing it.

Garlock Packing Service, is the title of Catalog A-1925, a 176-page, illustrated book published by the Garlock Packing Co., Palmyra, N. Y. The first part of the book describes and illustrates in detail the various types of Garlock packing and the methods of packaging them. The next section discusses various packing and gasket services rendered by the company and a detailed discussion of metal packing is presented with blueprints, text and many photographs. Tables of engineering data of assistance in selecting packing are given at the end of the book, which is well illustrated and attractively arranged.

Important developments in national standardization activities of almost every major American industry are discussed in the American Standards Year Book, a review of national industrial standardization movement during the past 12 months, just published by the American Standards Association, 29 West 39th St., New York City. The Review covers mechanical, electrical, building, mining, textile and many other industries. New standards completed during the year and new projects initiated are discussed in detail and the advantages of industrial standardization are enumerated.

Modern Central Stations, Fifth Section, has just been published by Ingersoll-Rand Co., 11 Broadway, New York. This is the fifth of a series of loose-leaf bulletins containing reprints of articles from the various technical magazines describing important new central stations. A few technical articles of general interest to the field are usually included, but for the most part the articles are detailed descriptions of the plants. They are published to collect in convenient form material of value and interest to designers and operators of central stations.

Bulletin No. 4-F describing steam jet thermo-compressors has recently been issued by Schutte & Koerting Company, 12th and Thompson Sts., Philadelphia, Pa. This is to replace the 1925 edition. The new bulletin describes not only the standard hand controlled thermo compressor covered in the previous edition, but also illustrates and describes the automatic thermo-compressor designed for use where close regulation is required. Advantages of the compressor are discussed; line drawings show some of its application in industrial and power plant work.

Nugent oiling systems for engines are described and illustrated in detail in a 48-page bulletin No. 15, edition 2, recently issued by Wm. W. Nugent & Co., 410 N. Hermitage Ave., Chicago, Ill. Details of the various types of oilers and engines are given, with illustrations and line drawings of their parts.

Pennsylvania single-stage, double-acting, straight line air compressors and vacuum pumps are described in bulletin 147 by the Pennsylvania Pump & Compressor Co., Easton, Pa. This well-illustrated, 24-page bulletin describes and illustrates compressor details such as shafts, connecting rods, valves and cylinder construction, shows machine assemblies and accessories and give tables of size, capacities and rating.

Sectional Cast Iron storage tanks of octagonal and semi-octagonal form with sloping bottom, for fuels and granular material are shown in bulletin No. 14 issued by Hahn Engineering Co., Lancaster, Pa.

Properties of Nickel and Nickel-Chromium cast iron are discussed in bulletin No. 207 issued by the International Nickel Co., Inc., 67 Wall St., New York. Applications for such uses as engine, pump and compressor cylinders, sleeve valves, gears, fans, casings, valve bodies, stoker park and resistance grids are shown.

Coal and Ash handling and weighing equipment at the plant of Briggs Mfg. Co., Detroit, is described in No. 167 of the Labor Saver bulletin, issued by Stephens-Adamson Mfg. Co., Aurora, Ill.

Complete details of first aid cabinets and first aid materials are given in Catalog No. FA-1, recently issued by the Mine Safety Appliances Co., Pittsburgh, Pa. This shows the various types of bandages, sterile gauze, adhesive plaster and other equipment used in first aid work; it describes and illustrates various types of first aid cabinets for all purposes.

Manufacture of nickel steel plate, reprinted from the Transactions of the American Society of Mechanical Engineers, is issued as bulletin 14 by the International Nickel Co., Inc., 67 Wall St., New York, N. Y.

Report of the Committee on Heat Transmission, division of engineering and industrial research, National Research Council, 40 W. 40th St., New York, N. Y., has recently been issued. This constitutes a code for the determination of heat transmission valves for that class of substances used as solid electrical insulators.

Dodge Belt Conveyors are described in detail in catalog A-108, issued by Dodge Mfg. Corp., Mishawaka, Ind. This is a 168-page book, profusely illustrated with halftones, diagrams and charts. It first discusses design of conveyors and their various parts and gives tables of dimensions and belt speeds, charts for determining various factors needed and contains many tables of dimensions and sketches of various parts of the conveyors.

Introduction to Nickel Cast Iron, a brief discussion of the position of cast iron in the engineering field, the trend toward improvements in physical and mechanical properties and the role of alloys in this connection, is the title of Bulletin 201-a, recently issued by The International Nickel Co., 67 Wall St., New York City. The company is also issuing Bulletin 207, Properties and Applications of Nickel and Nickel-Chromium Cast Iron. Superseding bulletin No. 201 under this title, the present publication has been expanded to include more than 25 important applications of nickel cast iron. Many examples of the economic value of the material are discussed and illustrated.

Power Plant Construction News

Ariz., Bisbee—The Calumet & Arizona Mining Co., Calumet, Mich., is reported planning the complete electrification of its mining plants at Bisbee and Douglas, Ariz., in connection with a general expansion and improvement program, entire project to cost more than $2,000,000.

Calif., San Jose—The Garden Valley Canning Co., care of William F. James, First National Bank Building, representative, plans installation of power equipment in proposed local canning plant, entire project to cost about $100,000.

Conn., Bantum—The South New England Ice Co., plans rebuilding of portion of local plant, including storage and distributing division, recently destroyed by fire with loss reported at more than $175,000.

Conn., Bridgeport—The United Illuminating Co., New Haven, Conn., has filed plans for an addition to turbine room and switchhouse at its Steel Point power plant, East Main Street, Bridgeport, to be three-story, 80x150 ft., reported to cost more than $300,000, with equipment. Westcott & Mapes, New Haven, are engineers.

Conn., Hartford—The Chance Vought Aircraft Corporation, Long Island City, N. Y., will install power equipment in proposed new plant at Hartford, Conn., entire project reported to cost close to $1,000,000. Albert Kahn, Inc., Marquette Building, Detroit, Mich., is architect and engineer.

Fla., Fort Pierce—The Sandiford Fish & Shrimp Packing Co., Fort Pierce, plans the construction of a cold storage and refrigerating plant, reported to cost more than $40,000, with equipment.

Fla., Tampa—The United States Phosphoric Corporation plans installation in proposed plant in the Hillsborough Bay district, entire project to cost more than $500,000. Plans for initial unit have been approved.

Ga., Rockmart—The Goodyear Tire & Rubber Co., Akron, Ohio, plans installation of power equipment in connection with proposed new tire fabric mill near Rockmart, entire project reported to cost more than $1,000,000. A boiler plant is projected.

Ill., Bloomington—The City Council plans installation of pumping equipment and power machinery in connection with proposed extensions and improvements in municipal power and water plants, for which plans will be drawn by the Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., consulting engineers.

Ind., Milroy—The Milroy Milling Co., is said to be planning the installation of power equipment, conveying apparatus and other mechanical equipment, in connection with proposed rebuilding of portion of grain and feed-milling plant, recently destroyed by fire with loss reported in excess of $100,000.

Iowa, Storm Lake—The Iowa Public Service Co., Sioux City, Iowa, has authorized the immediate construction of an electric power plant at Storm Lake, reported to cost about $35,000, with equipment.

Md., Amcelle—The Celanese Corporation of America, Inc., Amcelle, near Cumberland, plans installation of power equipment in proposed new three-story addition to rayon mill, entire project to cost $150,000.

Mass., Holyoke—The Holyoke Power Co., Holyoke, has plans maturing for the construction of a hydroelectric power plant on its water power right-of-way, near the mill of the American Writing Paper Co., reported to cost about $400,000, with equipment.

Mass., Springfield—The Strathmore Paper Co., Mittineague, Mass., is reported planning a one-story hydroelectric power plant for mill operation, to cost in excess of $65,000, with equipment. L. R. Howe is company engineer.

Mich., Detroit—The Chevrolet Motor Car Co., West Grand Boulevard, plans installation of power equipment in proposed new one and two-story addition to plant, entire project to cost about $200,000. Albert Kahn, Inc., Marquette Building, is architect and engineer.

Mich., Detroit—The General Baking Corporation, 420 Lexington Avenue, New York, plans installation of power equipment, traveling ovens and other mechanical equipment, in connection with proposed baking plant to cost approximately $850,000. A similar plant will be built at Allentown, Pa., to cost about $300,000.

Mo., Cadet—The National Pigments & Chemical Co., 1 Sidney Street, St. Louis, Mo., is said to be planning the installation of power equipment in connection with proposed rebuilding of portion of plant at Cadet, recently destroyed by fire, with loss reported at close to $100,000.

N. J., Camden—The General Cold Storage Co., 328 Market Street, recently organized by J. P. Murray, 4813 Springfield Avenue, Philadelphia, Pa., and associates, with capital of $1,000,000 is reported planning early establishment of an ice and cold storage plant in this vicinity, to cost upward of $100,000, with equipment.

N. Y., Amsterdam—The Mohawk Carpet Mills, Inc., has plans under way for a new boiler plant to cost more than $200,000, with equipment, project to be carried out in connection with a general expansion program at the mill to cost upward of $800,000.

N. Y., Poughkeepsie—The Palatine Aniline & Chemical Corporation, North Water Street, plans installation of power equipment in proposed rebuilding of portion of plant recently destroyed by fire with total loss reported close to $100,000.

N. Y., Niagara Falls—The Niacet Chemicals Corporation, Pine Avenue, plans installation of power equipment in connection with plant expansion, entire project to cost more than $600,000. Waldo C. Hovey is manager.

Ohio, Cleveland—The Lincoln Electric Co., Coit Road, plans installation of power equipment in connection with an addition to its electric welding equipment manufacturing plant, reported to cost more than $75,000.

Ohio, Cleveland—The Whiteway Stamping Co., 1201 East Fifty-fifth Street, plans installation of power equipment in connection with proposed new plant on East Seventieth Street, entire project to cost more than $100,000.

Ohio, Toledo—The Toledo Grain & Milling Co., Toledo, plans installation of power equipment in connection with proposed rebuilding of portion of feed mill, destroyed by fire July 28, with loss reported in excess of $250,000.

Okla., Oklahoma City—The Western Paint & Chemical Co., Maple Avenue, plans installation of power equipment in connection with proposed rebuilding of portion of plant, recently destroyed by fire, with loss reported in excess of $100,000.

Okla., Sayre—The Farmers Gin Co., Sayre, plans installation of power equipment in proposed group of cotton oil mills, entire project to cost close to $100,000.

Pa., Gibsonton—The Pittsburgh Steel Co., Union Trust Building, Pittsburgh, will install power equipment in proposed new byproducts plant at Gibsonton, entire project reported to cost more than $2,000,000.

Pa., Oil City—The Pennzoil Co., operated by the South Penn Oil Co., has work under way on expansion and improvement program at its local oil plant to include a new boiler house, pumping station and other mechanical units.

Tenn., Elizabethton—The American Glanzstoff Corporation, Elizabethton, plans installation of power equipment, in connection with new addition to rayon mill, entire project to cost in excess of $1,000,000. Increase will be made in present power facilities. Headquarters are at 180 Madison Avenue, New York.

Va., Fredericksburg—The Sylvania Industrial Corporation, 122 East Forty-second Street, New York, plans installation of power equipment in proposed new mill on tract of 200 acres of land at Fredericksburg, for the manufacture of transparent papers, entire project reported to cost more than $800,000. A boiler plant is projected. Dr. Frank H. Reichel is general manager.

Wash., New Castle—The Pacific Coast Coal Co., New Castle, plans rebuilding of portion of coal washing, storage and distributing plant, recently destroyed by fire, with loss reported at close to $100,000.

Wash., Spokane—The American Fire Brick Co., Spokane, plans installation of boiler and other power equipment in connection with extensions and improvements of local plant of the Andrew Laidlaw Pottery, recently acquired for new works.

Wis., Milwaukee—The Snap-On Wrench Co., 1270 South Pierce Street, plans installation of power equipment in proposed new plant addition, entire project reported to cost more than $120,000.